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Investigating the relationships among primary teachers' math profile, math teaching efficacy, and math content pedagogical knowledge

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INVESTIGATING THE RELATIONSHIPS AMONG PRIMARY TEACHERS' MATH PROFILE, MATH TEACHING EFFICACY, AND MATH CONTENT PEDAGOGICAL KNOWLEDGE

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Theresa Marie Roettinger

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Abstract

INVESTIGATING THE RELATIONSHIPS AMONG PRIMARY TEACHERS' MATH PROFILE, MATH TEACHING EFFICACY, AND MATH CONTENT PEDAGOGICAL KNOWLEDGE

Kindergarten, first and second grade teachers play an important role in the development of a student's understanding of mathematics. Consequently, in order to improve student achievement in mathematics, it is important to investigate the relationships that may exist among primary teachers' math profile, math teaching efficacy, and math pedagogy and content knowledge. Participants completed an online survey that included the Math Teaching Efficacy Belief Instrument (MTEBI) and Math Knowledge for Teaching (MKT) items. Participants provided math profile data through academic demographic questions.

Two-hundred seven respondents completed the survey. Analysis of the data included descriptive statistics, chi-square test of independence, and Spearman rho correlations. The descriptive statistics of this sample population indicated varied math professional learning experiences, reserved mathematic teaching efficacy and little expertise in the knowledge of third grade mathematics. Relationships between frequency of math professional learning and math teaching efficacy emerged as statistically significant and merit further investigation. Additional statistically significant relationships occurred between math content knowledge and math teaching efficacy. The strength of these relationships was moderate and warrant further investigation.

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INVESTIGATING THE RELATIONSHIPS AMONG PRIMARY TEACHERS' MATH PROFILE, MATH TEACHING EFFICACY, AND MATH CONTENT PEDAGOGICAL KNOWLEDGE

Chapter 1.

Teachers of kindergarten, first grade and second grade play an important role in helping students develop a foundational understanding of mathematics (Nye, Konstantopoulos, & Hedges, 2004). In Virginia, students are required to demonstrate their level of mathematical understanding on a third grade state assessment. From the Spring of 2011 to the Spring of 2012, results of the third grade state assessment of mathematics in Virginia showed a statistically significant decline (Virginia Department of Education, 2012, September). Only 64% of all third grade students passed the Grade 3 Math Virginia Standards of Learning (SOL) in the spring of 2012, as compared with 91% of all third grade students the previous spring. This SOL assessment is a culmination of mathematic skills taught and developed through the mathematics curriculum in kindergarten, first, second, and third grades. Consequently, these results raise a question as to whether kindergarten, first, and second grade teachers have a solid understanding, or possess the critical knowledge of mathematics content and pedagogy, necessary to prepare their students for the third grade mathematics course. Could a lack of teacher math content knowledge influence a student's ability to understand mathematics concepts that are more demanding?

Teachers of kindergarten, first, and second grade students are responsible for helping students develop the foundational mathematical knowledge upon which they will later build (Nye, et al., 2004). Currently in Virginia, the three license types that allow teachers to teach in the primary grades are PreK-3, PreK-6, and PreK-8 (Virginia Department of Education, 2011). According to the Virginia Department of Education licensure manual (2011), the requirements for the PreK-3 license are 60 semester hours with 9 of those semester hours in mathematics. The requirements for the PreK-6 license include 72 semester hours with 12 of those semester hours in mathematics. In addition, there are four routes to licensure in the state of Virginia (2012, July): approved program, reciprocity, alternative licensure, and alternative route for career professions. Teachers licensed through an approved program can have varying course requirements. Post-secondary institutions that have a teacher preparation program must have had their program approved by the Division of Teacher Education and Licensure for a graduate of their program to gain a Virginia teaching license (Virginia Department of Education, 2011). The reciprocity route has four conditions for licensure for out-of-state teachers. If a person meets one of the four conditions, the state grants them a Virginia teaching license in a comparable endorsement area.

Alternate licensure is available through the recommendation of the employee's school district. The State Department of Education will issue the person a nonrenewable three-year license. The person must complete any identified course work. For early/primary education PreK-3 and elementary education PreK-6, the person may be required to complete 18 semester hours, of which no mathematics coursework is required. In addition, the person electing to engage in an alternative route must have been accepted into an approved Career Switch Program, have a baccalaureate degree, at least five years of full-time work experience, and earn qualifying scores on Virginia's professional teacher assessment. A principal hires and assigns primary grade teachers into grade levels based on the endorsement type. Are these various licensure path requirements sufficient to ensure that the teachers' mathematics skill set is adequate to the task of helping students' develop an understanding of foundational topics?

Virginia has had high-stakes mathematics assessments for students in grades three, five, and eight, and as end-of-course tests in algebra one, geometry, and algebra two since 1996 (Virginia Department of Education, 1996). The U.S. Department of Education (2004) through The No Child Left Behind Act (NCLB) requires students to demonstrate a passing level of proficiency on mathematics state assessments, starting at the completion of third grade. Yet, within an educational climate that requires high-stakes testing and an increasingly rigorous curriculum, there is no accountability system in place to determine whether students are learning the necessary mathematics curriculum and skills in kindergarten, first grade and second grade. Identifying variables that can aid the collection of data about teacher influence in primary grade level classrooms is worthy of investigation.

Statement of the Problem

NCLB mandates that students demonstrate sufficient knowledge in both reading and mathematics, starting at grade three, for schools to earn the status of meeting Annual Yearly Progress (Virginia Department of Education, 2010a). Failure to meet this expectation can lead to loss of federal resource support and other sanctions (Virginia Board of Education, 2009). The Virginia 2009 Mathematics Standards of Learning

(2010e) require primary teachers to understand a more difficult curriculum with increased conceptual rigor and to possess the corresponding pedagogical skills necessary to create the strong foundation required in order for students to excel in mathematics in third grade and beyond. An extensive search of the literature, found no research studies focused on the variables that demonstrate primary grade teacher effectiveness. Therefore, an identification and examination of relationships between significant variables is warranted.

Conceptual Framework

Teachers are a key component of the educational process (Hattie, 2012). Student achievement has been correlated with the effectiveness of the teacher. Hattie (2012) states, "The differences between high-effect and low-effect teachers are primarily related to the attitudes and expectations that teachers have when they decide key issues of teaching" (p. 23). The teacher's attitudes and belief systems make a difference in the way they teach (Hattie, 2012). From this research, two variables emerge that may require further research, namely, a teacher's attitudes and beliefs about teaching mathematics, as well as the teacher's ability to decide how to teach content.

A teacher's content and pedagogical knowledge are influenced by his or her own educational experiences. A teacher must either complete required course work or meet certain state mandated criteria. One path to becoming a teacher is by completing a state approved teacher preparation program at a college or university. The structure of the teacher preparation programs can provide some insight into what aspects college programs consider important in developing a highly qualified teacher.

In investigating conceptual frameworks from educational institutions that prepare teachers for the field of teaching, particular emphases are evident. For example, the College of Education at Idaho State University (2008) constructed a conceptual framework that shows the need for connecting the learner to curriculum, instruction, and assessment. The University of Alabama Education Department (2007) outlines a similar conceptual framework that addresses the "Process of Instruction" as one component of developing highly qualified teachers. Within this framework, instructional practices, knowledge, as well as assessment and evaluation criteria, have been identified as necessary components for an effective instructional process. In the state of Virginia there are 38 post-secondary institutions that have a Virginia approved PK3 or PK6 endorsement programs. Of these institutions, eight have only graduate endorsement programs (Virginia Department of Virginia, 2013). In comparing the 30 undergraduate programs, only 14 programs had a conceptual framework that were accessible (see Appendix A). Twelve programs' conceptual frameworks included knowledge or content as a key component.

A competent teacher has the skills necessary to teach students so they understand the content and skills required in the curriculum; possess the ability to solve real-life situational problems; and connect prior knowledge to future learning (Nye, et al, 2004). This study investigated the relationships among three key variables: math teacher profile, teachers' mathematics teaching efficacy, and mathematics pedagogical content knowledge. In the present study, the content knowledge was the Virginia Third Grade Mathematics Standards of Learning (Virginia Department of Education, 2010e). The assessment development included aligning the content vertically from kindergarten through to the grade three curriculum (Virginia Department of Education, 2010d). It is important that the teacher can identify the required current and future content and skills. Teachers must know more than the current curriculum, but they must also know the culmination expectations.

Not only must primary teachers know the curriculum content found at these four grades (i.e., K-3), they must also possess the pedagogical knowledge necessary to inform their instructional decisions (Ball D. L., n.d.). Figure 1 outlines the possible relationships these variables play in the role of a competent primary teacher of mathematics.

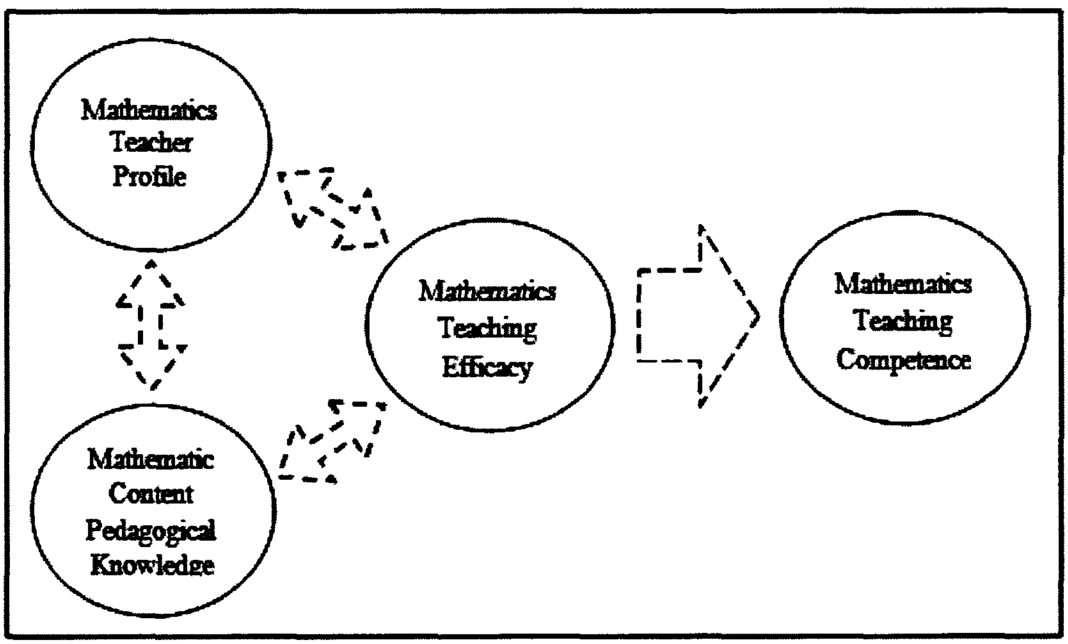


Figure 1. Conceptual framework diagram for the hypothesized relationships between mathematics teacher profile and mathematics content pedagogical knowledge with the mathematics teaching efficacy of the competent primary mathematics teacher

Research Questions

In this study, the researcher hoped to uncover the answers to the following questions:

1. To what extent are primary grade teachers (a) proficient with third grade pedagogical and content knowledge in mathematics, (b) efficacious in mathematics teaching, and (c) experienced in teaching mathematics?
2. What relationship exists between teachers' third grade mathematics pedagogical and content knowledge and
    a) college preparation experiences:
       (1) mathematics major, (2) degree level, (3) endorsement type(s);
    b) number of years teaching experience:
       (1) primary elementary, (2) upper elementary, and (3) middle school grades;
    c) professional development experiences:
       (1) number of post-college math courses taken, (2) completion of the national board certification process, and (3) frequency level of participation in mathematics professional development opportunities?
3. What relationship exists between the level of teachers' mathematics teaching efficacy and:
    a) college preparation experiences:
       (1) mathematics major, (2) degree level, (3) endorsement type(s);
    b) number of years teaching experience:

(1) primary elementary, (2) upper elementary, and (3) middle school grades;

c) professional development experiences:

(1) number of post-college math courses taken, (2) completion of the national board certification process, and (3) frequency level of participation in mathematics professional development opportunities?

4. What relationship exists between the level of teacher's mathematics teaching efficacy and the primary grade teacher's proficiency with third grade mathematics pedagogical and content knowledge?

Definition of Terms

The significant terms used in this study are listed below along with a clarifying definition.

Competent primary mathematics teacher: Hospesovà and Tichà (2005) define this as "a set of professional skills and dispositions that the teacher should possess in order to carry out his/her job effectively" (p. 1).

Content pedagogical knowledge: Ball, Thames, and Phelps (2008) define this as the combination of knowledge of content and student and knowledge of content and teaching. The knowledge of content and student requires teachers to know how students interact with the learning of math and the common errors that students make. The knowledge of content and teaching requires a teacher to know how to teach mathematics in such a way that students understand. Teachers need to know more than the algorithms; they need to know why the algorithm works so that they have a deeper understanding of the why and how math works.

Highly qualified teacher: The Office of Public Policy and Innovation from the U.S. Department of Education's (2003) definition is teachers that "hold a minimum of a bachelor's degree from a four-year institution; hold full state certification; and demonstrate competence in their subject area" (p. 4).

Mathematics teaching efficacy: Leder's (2002) definition is "a teacher's belief in his or her own capabilities of designing and using meaningful mathematics instruction" (p. 156).

Mathematics teacher profile: A composite of a teacher's history that includes teacher's college preparation experiences, work experiences, and professional development experiences.

Primary Teacher: At the time of sampling, a teacher that teaches in one of the following grade levels: Kindergarten, First, or Second.

Assumptions

The federal government requires that teachers be certified as highly qualified in the content or area in which they teach (U.S. Department of Education, 2004). When a teacher meets the necessary requirements to be deemed highly qualified by federal definitions to teach primary grades, the assumption is that the teacher also meets the standards to be highly qualified to teach mathematics at that primary grade. For a new elementary teacher who has taught fewer than three years to be deemed highly qualified, he or she must have a bachelor's degree and demonstrated mastery of writing, reading, and mathematics on a rigorous state created or approved assessment such as the Praxis. For a teacher who has been teaching for three or more years, the requirements for being deemed highly qualified are slightly different. Either the teacher has a bachelor's degree and has either passed the previously mentioned state assessment or has demonstrated "competence in all academic subjects in which the teacher teaches based on a high objective uniform state standard of evaluation" (U.S. Department of Education, 2004, section 23).

It is also assumed that if a teacher has a grade-specific teaching endorsement, he or she knows the math content required of students in the grade levels contained in the endorsement. For example, a teacher who has a PK-3 teaching endorsement should know the mathematics required in pre-kindergarten, kindergarten, first grade, second grade, and third grade.

Limitations

Compentency of a teacher includes many more variables than effiicacy, pedagogical conent knowledge and professional learning profile experiences. It is outside the parameters of this study to identify and measure all characteristics and traits that create a competent primary mathematics teacher. This study focused on three constructs.

A second limitation is that currently there are no national or state level data collection instruments that measure the growth of students in grades kindergarten, first, or second. One true measure of a successful teacher would be the yearly growth found with each student in the classroom. Without student growth data, it is difficult to make conclusive findings. The conceptual model is based on research that has found that a teacher with high teaching efficacy will have high student achievement and growth.

A final limitation is that this research did not collect participant achievement data such as the Praxis or GRE scores. These data could be a standard achievement measure that would provide for strong comparison.

Summary

What mathematics children learn in the primary grades has a foundational impact on their preparedness for learning in the upper elementary grades as well as in middle and high school. A joint position paper from the National Association of Education of Young Children and the National Council of Teachers of Mathematics (2002), emphasizes that the primary grades not only lay the foundation for the critical reading aspects of the curriculum, but they are also fundamental in the development of number sense, mathematical reasoning, and problem solving for young children. The next chapter identifies some of the critical components for primary mathematics teacher development.

Chapter 2. Literature Review

This chapter provides a backdrop for the motivation for this research. A broad look at the research concerning mathematics teachers' professional growth, math teaching efficacy, and mathematic content pedagogical knowledge will provide a detailed picture of some important factors that support teacher growth and improvement.

Math Teaching Professional Growth

General focus. Intuition suggests that the number of years a teacher spends teaching in the classroom should affect the level of teaching proficiency exhibited in the classroom. If a teacher is open to working, reflecting, and improving the craft of teaching, then each year of experience should result in some kind of change in subsequent years (McGraner, Van DerHeyden, & Holdheide, 2011). McGraner, Van Dereyden, & Holdheide (2011) suggest that "Revisioning teacher education as sustained and continuous teacher learning that begins at the preservice stage and continues throughout a teacher's career is critical to the advancement of teaching and learning in our schools" (p. 2).

Expert teachers change the lives of the students that they teach. Additional research has found that students assigned to three effective teachers in three consecutive years perform at the 83rd percentile in math at the end of fifth grade, whereas students assigned to three ineffective teachers in three consecutive years perform only at the 29th percentile (Sanders & Rivers, 1996). The cumulative effects of learning from a highly effective teacher can substantially reduce differences in student achievement that are due to family background (Rivkins, Hanushek, & Kain, 2005).

Yuen (2012) found that the current curriculum and responsibilities of the teacher should frame continuing professional development for teachers. Such professional development must be relevant to the teacher's work and be pertinent to the teacher's current needs. Not all teachers need the same professional development experiences. Darling-Hammond and McGaughlin (2011) discussed the need for teacher development activities to occur beginning with preservice teachers and continuing throughout the entire career. The focus should be on deepening the skills and strategies that teachers should use in their classrooms. Teachers should be both learners and teachers and should be student-achievement focused. The key characteristics of effective professional development include the following: engaging and meaningful for the participants, grounded in theory and reflection, focused collaboration, connected to the teacher's current context, allocated the appropriate amount of time so that it is sustained and ongoing, and supported within the building (Darling-Hammond & McGaughlin, 2011).

Avalos (2011) reviewed literature on professional development published over the course of the past ten years. She found that "teacher learning and development is a complex process that brings together a host of different elements... but at the center of the process, teachers continue to be both the subjects and objects of learning and development" (p.17). Duke (1993) concluded through research on adult growth and development that there is a variety of barriers that must be addressed when conducting professional development. Some of the barriers mentioned include a lack of self-awareness, high comfort level with current practice, fear of failure, and distrust. In addition, Lappan (2000) found that the research showed some important characteristics of effective professional development. These characteristics included student growth and achievement as a key learning goal, a strong correlation with the teacher's required curriculum and standards, a teacher's existing beliefs and knowledge, and support for change takes more than one school year.

In many professional fields, research has highlighted various models of professional growth over time. One such model, Dreyfus and Dreyfus (1980), originated from research with air force pilots and concluded that there are actually five stages in professional growth. The researchers found that pilots develop from "novice," to "advanced beginner," to "competent," to "proficient," and then finally arrive at the "expert" stage. These stages require pilots to make paradigm shifts from abstract understandings to providing concrete examples from personal experience. These professionals go from seeing their job as discreet unrelated parts to understanding the practice as a whole. They grow from a detached observer to an involved performer. Lester (2005) consolidated Dreyfus and Dreyfus's work in chart form, as noted in Figure 2. Figure 2 describes the five stages of change over the five domains. The five domains include, knowledge, standard of work, autonomy, coping with complexity, and perception of context.

	Knowledge	Standard of work	Autonomy	Coping with complexity	Perception of context
1. Novice	Minimal, or 'textbook' knowledge without connecting it to practice	Unlikely to be satisfactory unless closely supervised	Needs close supervision or instruction	Little or no conception of dealing with complexity	Tends to see actions in isolation
2. Beginner	Working knowledge of key aspects of practice	Straightforward tasks likely to be completed to an acceptable standard	Able to achieve some steps using own judgement, but supervision needed for overall task	Appreciates complex situations but only able to achieve partial resolution	Sees actions as a series of steps
3. Competent	Good working and background knowledge of area of practice	Fit for purpose, though may lack refinement	Able to achieve most tasks using own judgement	Copes with complex situations through deliberate analysis and planning	Sees actions at least partly in terms of longer-term goals
4. Proficient	Depth of understanding of discipline and area of practice	Fully acceptable standard achieved routinely	Able to take full responsibility for own work (and that of others where applicable)	Deals with complex situations holistically, decision-making more confident	Sees overall 'picture' and how individual actions fit within it
5. Expert	Authoritative knowledge of discipline and deep tacit understanding across area of practice	Excellence achieved with relative ease	Able to take responsibility for going beyond existing standards and creating own interpretations	Holistic grasp of complex situations, moves between intuitive and analytical approaches with ease	Sees overall 'picture' and alternative approaches; vision of what may be possible

Figure 2. Novice to Expert Scale adapted from Dreyfus and Dreyfus (Lester, 2005)

Guskey (2000) developed a model for professional development that emphasizes the need to measure professional development as a change in teacher's attitudes and beliefs (see Figure 3). After the teacher has completed a professional development session, the expectation is that the teacher uses the knowledge gained in the session in the classroom. Once teachers see a positive effect on the student's learning, only then will the teacher's beliefs and attitudes change.

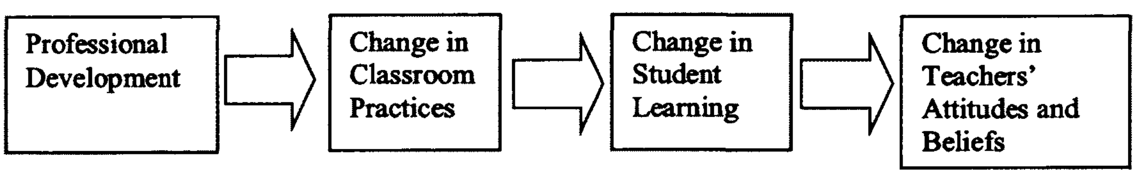


Figure 3. A Model of Teacher Change (Guskey, 2000, p139)

Figure 4 illustrates Witterholt's (2012) finding that professional growth is more cyclical in nature. Teachers learn from the external source of information, apply and experiment with the student learning, and then change their beliefs and attitudes from the student outcomes. All pieces of this professional growth map are interconnected. Learning does not happen in isolated instances, but instead on a continuing basis.

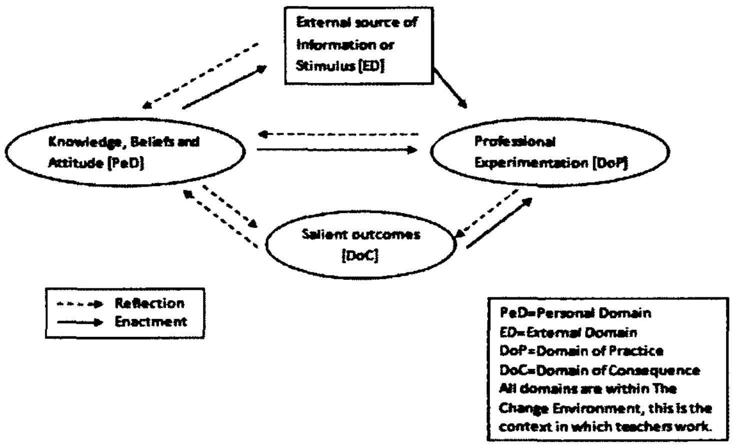


Figure 4. The Interconnected Model of Professional Growth (Witterholt, 2012)

These various professional learning models provide some points to reflect upon. Several factors are emphasized that help identify various teacher growth opportunities. Dreyfus and Dreyfus (1980) provide a model that implies experience develops through time working on the work. Through working on the work, a professional grows in knowledge, standard of work, autonomy, coping with complexity, and perception of context. Guskey (2000) provides a model that tries to explain how to produce change in teachers' attitudes and beliefs by professional development opportunities that encourage change in classroom practices, which causes changes in student learning outcomes, which then changes teachers' attitudes and beliefs. Witterholt (2012) provides a model that shows professional learning as circular and never-ending. Consideration of these three models, along with Darling-Hammond and McGaughlin's (2011) findings, lends strength to the exploration of the following aspects of teacher professional growth: types of professional development experiences, educational course work, professional authoring opportunities, and mentorship.

Virginia focus. Since this research study will be focusing on Virginia specifically, it is necessary to discover the requirements for professional learning for teachers within that state. The Virginia Department of Education (2012, June) requires that every five years teachers must renew their teaching license. In order to have a teacher license renewed, a teacher must complete 180 hours of recertification points. Teachers earn recertification points by completing one or more specified options. These options include the following: (a) college credit (up to 180 recertification points); (b) professional conference (up to 45 recertification points); (c) curriculum development (up to 90 recertification points); publication of article (up to 90 recertification points); (d) publication of book (up to 90 recertification points); (e) mentorship/supervision (up to 90 recertification points); (f) educational project (up to 90 recertification points); or (g) professional development activities (up to 180 recertification points).

Most teachers earn recertification points on a per hour basis, with a minimum of five hours working on a specific project. College course credits are awarded at 30 recertification points per credit hour, with a three-credit course earning 90 recertification points. This course work is supposed to be comprised of content related to a teacher's current job position. Some combination of this list of professional exercises must occur within the five-year period. These activities constitute a form of professional development.

Content Pedagogical Knowledge

General content and pedagogy. For the pre-service teacher, Darling-Hammond (2006) noted three critical components of teacher education programs. She described the need for alignment between the required courses, the course work, and the practicum experiences. Her point being that all too often the course work is mostly theoretical in nature and not truly applicable to the classroom. The required course curriculums should incorporate and reflect a strong effective teacher. Her other point is that the practicum is not always a well-structured experience.

Teachers in training need to have realistic, supported, and well-supervised experiences in the practicum. Teaching delivery and feedback in the required coursework experiences at the college should model the same practices that should be occurring in the practicum experiences (Darling-Hammond L. , 2000). These activities must inform and prepare the pre-service teacher for practicum experiences inside of a real classroom with students. The pre-service teacher's work should have meaning and value.

In addition, the pre-service teacher needs a strong relationship with a supervising expert. The practicum experience should model pedagogies demonstrated in the course work that link theory with practice (Darling-Hammond L. , 2006). A close network must exist between the pre-service teacher, the supervisor, and the school community in which the pre-service teacher is practicing. This strong relationship will ensure that pedagogical and content knowledge is monitored, reflected upon, and improved.

Hill (2010) completed a research project with 625 students. She used the Measuring Knowledge for Teaching (MKT) multiple-choice style assessment covering elementary topics. The assessment found that items requiring specialized knowledge for teaching mathematics proved to be more difficult for the participants. Teacher participation in leadership activities and self-reported college-level mathematics preparation seemed to have little influence on the teacher's levels of mathematic pedagogical content knowledge.

Hill and Ball (2009) stated that the MKT questions have been administered to a variety of large groups. The use of the instrument in various settings allows research to learn more about the kinds of mathematics teaching knowledge necessary to influence student learning. A group of economists applied this bank of research-developed items for a study (Rockoff, Jacob, Kane, & Staiger, 2008). Four hundred and eighteen teachers completed the survey, which contained MKT questions along with questions that measured cognitive ability and several personality traits. The economists found that the MKT questions were the only significant predictor of student outcomes. The MKT was strongly related to the mathematical quality of instruction.

To be competent, teachers must possess the necessary knowledge and skills required to teach their students (Ball, Hill, & Bass, 2005). The teacher's level of content and pedagogical knowledge is the primary resource available to the teacher to prepare students for continued success in mathematics. Students gain the foundation for understanding third grade mathematics in the primary years of schooling (Nye, et al, 2004). The art of teaching involves not only knowing what is in one's own curriculum, but also how curriculum at a particular grade level influences curriculum understanding in future years, and especially in the third grade year when mastery level will be measured (Ball, Hill, & Bass, 2005).

Primary teachers must have a level of content pedagogical knowledge and content expertise in the craft of teaching young students that is parallel to that of their high school counterparts (Ball, et al., 2008). Much like the Common Core State Standards (2010) for mathematics, the Virginia mathematics curriculum for the primary grades was revised a number of times to increase rigor for students (Virginia Department of Education, 2010b).

In Ma's (1999) book, she reinforces the notion that teachers need to be an expert in both the mathematics content that they are teaching, but also an expert in communicating this knowledge with students. Teachers must be able to take what they know and understand and express it in multiple ways so that all students can learn and achieve.

Research work at the University of Michigan described this level of content knowledge as noted in Figure 5 (Ball, et al., 2008).

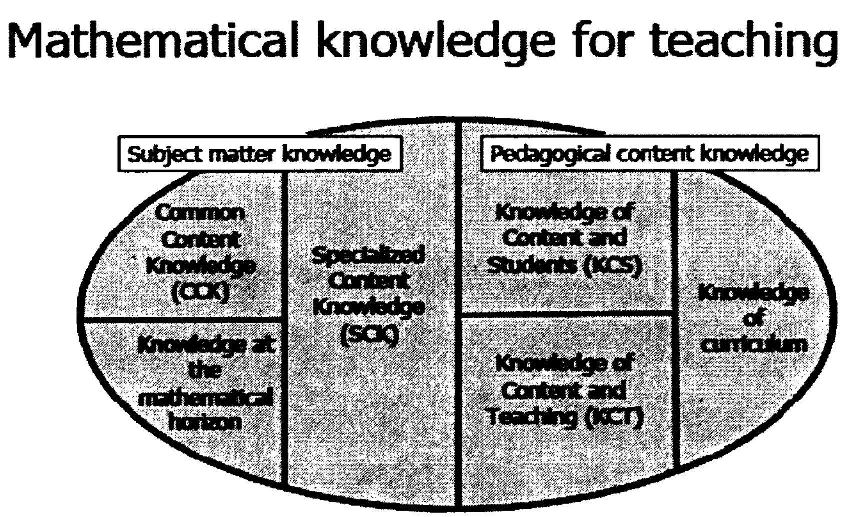


Figure 5. Shulman's original category scheme (1986) compared to Ball, Thames, and Phelps (2008)

Figure 5 expands upon the research completed by Shulman (1986) regarding pedagogical content knowledge and identifies two more narrowly focused aspects. Common content knowledge, specialized content knowledge, and knowledge at the mathematical horizon form subject matter knowledge (Ball et. al., 2008). When taken with knowledge of content and students, knowledge of content and teaching, and knowledge of curriculum (i.e., pedagogical content knowledge), these components create mathematical knowledge for teaching. This pilot study focused on the common content knowledge (CK) and knowledge of content and students (KCS).

Virginia math content and pedagogy. At the completion of third grade, students will be measured and assessed on a high stakes assessment for the first time (Virginia Department of Education, 2010a). With this expectation, primary grade teachers should have the vertical understanding in both knowledge and teaching skills essential to prepare students for successful completion of the state-created third grade mathematics assessment. According to the Virginia Department of Education (2010c) Mathematics Crosswalk document, and as listed in Table 1, the kindergarten curriculum added three new content topics and made eight adjustments to the 2001 standards that increased the level of cognitive demand for the students. Students now must work with 15 and 10 objects instead of just 10 or 3 objects. Students who were expected to count to 30 must now count forward to 100 by ones, fives, and tens. New content focuses on an introduction to fractions as well as knowing one more and one less than a number. Students must model adding and subtracting. With data, students must answer questions related to the data. There were ten curriculum standard changes.

Table 1

Mathematics Standards of Learning – Kindergarten (2010)

2009	2001	Changes
K.2a	K.2a	Number of objects increased to 15 (from 10).
K.3	K.3, 1.5	Number of objects increased to 10 (from 3).
K.4a	K.5	Count forward to 100 (increased from 30).
K.4b	NEW CONTENT	Identify one more than and one less than a number.
K.4c	K.4	Count by fives and tens to 100 (increased from 30).
K.5	NEW CONTENT,(1.6)	Identify halves and fourths (not just the unit fractions).
K.6	K.6	*Model adding and subtracting* whole numbers, using up to 10 concrete objects (was "add and subtract").
K.9	K.9	Using analog *and* digital clocks (was "or").
K.11a	K.11	Identify, describe, and *trace* figures (was "draw").
K.14	K.15	New: Answer questions related to the data.

As noted in Table 2, there were thirteen curriculum standard changes in first grade. In number sense, the idea of zero is now introduced, and students will be expected to count by twos as well as count backwards from 30 instead of 20. Fraction concepts require students to now understand thirds, as well as halves, and fourths, and they are not limited to only knowledge about unit fractions. Students also need to know how to write and read the fractions correctly. Students need to know basic addition facts to 18, instead of to 10, as in the 2001 Math Standards. Thirteen new vocabulary words are included. Students must construct and model instead of simply identifying geometric figures in the world around them. Of these changes, one concept moved from third grade and another moved from second grade. These changes were made in addition to the new curriculum requirements (Virginia Department of Education, 2010c).

Table 2

Mathematics Standards of Learning – Grade 1 (2010)

2009	2001	Changes
1.1a 1.1,	1.4	Count from 0 to 100 (was 1 to 100).
1.2	1.3	Count forward by ones, *twos*, fives, and tens to 100. Count backward by ones from 30 (was 20).
1.3	NEW CONTENT, 1.6	New: Identify the parts of a set and/or region. Identify halves, *thirds*, and fourths (not just unit fractions). Write the fractions.
1.5	1.8	Sums and differences to 18 or less (was 10).
1.6	1.9	Sums and differences to 18 or less.
1.8	1.11	Using analog *and* digital clocks (was "or").
1.9	1.12	Measure length, weight/*mass*, *and volume*.
1.10a	1.13	New vocabulary: *more*, *less*, and *equivalent*
1.10b	1.14	Weight/*mass*. New vocabulary: *more*, *less*, and *equivalent*
1.11	2.18a	Using calendar language: names of the months, *today*, *yesterday*, *next week*, *last week*.
1.12	1.16	*Identify and trace* geometric plane figures (was "draw"). New vocabulary: *vertices* and *right angles*
1.13	1.17	*Construct*, *model*, and describe objects in the environment as geometric shapes (was "identify"). New: Explain the reasonableness of each choice.
1.18	3.25b	Demonstrate an understanding of equality using the equal sign.

As noted in Table 3, there were sixteen curriculum standard changes in second grade. Of these, five of the standards contain new content. Fractions concepts expanded to sixths and students now must compare unit fractions. Students must solve two-step addition and subtraction application problems. Now students must estimate and measure liquid volume, when the 2001 Math Standards only required them to compare. The time standard now requires students to tell time to the nearest five minutes instead of the nearest hour. Students must now identify, describe, compare, and contrast plane and solid figures, instead of simply sorting them. Students must analyze data found in graphs and make predictions. Students must understand both the equal and not equal symbols and use them correctly (Virginia Department of Education, 2010c).

Table 3

Mathematics Standards of Learning – Grade 2 (2010)

2009	2001	Changes
2.2b	NEW CONTENT	Write the ordinal numbers.
2.3a,b	2.4	Identify the parts of a set and/or region that represent fractions for halves, thirds, fourths, *sixths*, eighths, and tenths (not just unit fractions).
2.3c	NEW CONTENT	Compare unit fractions.
2.5	2.6	Sums and differences to 20 or less (was 18).
2.8	2.9	Create and solve one- *and two-step* addition and subtraction problems.
2.10a,b	2.11a, b	*Correctly use* cent and dollar symbols, and decimal point.
2.11a	2.12	Removed: Determine perimeter.
2.11b	2.15	Estimate and measure weight/mass in pounds/*ounces* and kilograms/*grams* using a scale.
2.11c	2.17	*Estimate and measure* liquid volume (was "compare").
2.12	2.16	Tell and write time to the nearest five minutes (was quarter hour).
2.15a,b	2.21, 5.15d	New: Draw a line of symmetry.
2.16	2.20, 2.22	Identify, describe, compare, and contrast plane and solid figures (removed "sort"). Removed: Square pyramid, cylinder, and cone. New vocabulary: rectangular *prism* (was "solid")
2.17	2.23	Use data from experiments to construct picture graphs, *pictographs*, and bar graphs
2.18	2.24	Use data from experiments to predict outcomes when the experiment is repeated.
2.19	NEW CONTENT	Analyze data displayed in picture graphs, pictographs, and bar graphs.
2.22	NEW CONTENT	Demonstrate an understanding of equality using the symbols = and ≠.

As noted in Table 4, there were seventeen curriculum standard changes in third grade. Fraction standards now include mixed numbers and comparison using words and symbols correctly. Students are required to solve multistep application problems. Memorization and fluency of multiplication facts changes from the nine's times tables to the twelve's times tables. Students must represent multiplication and division using number line models. There are eight new vocabulary words that third grade students must understand and use. The new content includes calculating elapsed time, identifying examples of the identity and commutative properties of addition and multiplication, and determining non-congruent geometric figures (Virginia Department of Education, 2010c).

Table 4

Mathematics Standards of Learning – Grade 3 (2010)

2009	2001	Changes
3.3a, b	3.5a, b	*Model* fractions (including mixed numbers) and write the fractions' names (was "divide regions and sets to represent").
3.3c	3.6	Compare fractions *using words and symbols (>, <, or =).*
3.4	3.8	*Estimate solutions to* and solve *single-step and multistep* problems.
3.5	3.9	Recall multiplication facts through the *twelves* table, and the corresponding division facts (was "nines").
3.6	3.10	Represent multiplication and division using area, set, *and number line models.*
3.7	3.11	Add and subtract proper fractions having like denominators of *12* or less (was "10").
3.9a,b,c	3.14a, b, c	Estimate and measure length to the nearest *½ - inch* (was "inch").
3.9d	NEW CONTENT	Estimate and measure area and perimeter.
3.10a	2.12	Measure length to determine the perimeter of a polygon.
3.10b	2.13	Count square units to determine area.
3.11a	3.15	Tell time to the nearest *minute.*
3.11b	NEW CONTENT	Determine elapsed time in one-hour increments over a 12-hour period.
3.14	3.18, 2.20	*Identify*, *describe*, *compare*, and *contrast characteristics*(was "properties") of plane and solid geometric figures. New vocabulary: *angles* and *vertices*
3.15	3.19	Identify and draw representations of *points*, line segments, *rays*, angles, and *lines.*
3.16 3.20,	4.17b	Identify and describe congruent *and noncongruent* plane figures. Removed: Symmetrical plane figures.
3.17a,b	3.21a,b	New vocabulary: *data* (was "results")
3.20b	NEW CONTENT	Identify examples of the identity and commutative properties for addition and multiplication

This is the content that primary teachers must understand and teach. Teachers must have more than an adult understanding of these topics; they must have the knowledge of content and students as well as the knowledge of content and teaching for each of these topics (Ball, et al,, 2005). Teachers must have the content pedagogical knowledge necessary to navigate the teaching and learning of these topics (Ball, et al., 2005). Kindergarten teachers need to understand how their teaching affects the curriculum content found in first, second, and third grades. This is the curriculum that students are tested. Teachers cannot decide not to teach a portion of it because they feel that this material is not developmentally appropriate. Teachers need to have a solid understanding of the curriculum and the pedagogy necessary to teach the curriculum to their students. Curriculum is the "what" and the pedagogy is the "how." These two pieces need to fit together for a teacher to be successful with teaching the curriculum.

Efficacy

Self-efficacy. Bandura's (1977) research found that self-efficacy is a self-perception about the amount of control and influence a person has over their life's choices. These beliefs affect the decisions and choices that a person makes in life. If a person feels like they have little or no power over daily events, they have a low self-efficacy and feel powerless in their environment. If a person feels high control over daily events, they tend to have a higher sense of self-efficacy and feel confident about the choices they make in life. People's beliefs in their efficacy can be formed by mastery experiences, by watching people they view as equal to themselves complete similar situations, by feeling that those around them believe that they can complete the tasks, or by intrinsically motivating themselves to move forward and complete the task.

Teacher efficacy. Gibson and Dembo's (1984) research study identified distinct differences between teachers with high teacher efficacy to those teachers with low teacher efficacy. The study observed how these two groups of teachers spent their teaching time. This research found that teaching efficacy is a complex idea.

Guskey and Passaro (1994) looked at the parallelisms found in the Gibson and Dembo's (1984) and found that the two constructs were written in similar fashion, personal efficacy using "I" and teaching efficacy used "the teacher". Also, personal efficacy items were written in more positive way where the teaching efficacy items were written in a more negative way. Guskey and Passaro (1994) re-worked the items so that the items were mixed in format. This study found from the factor loadings that there were two different yet related constructs that could be defined as external and internal.

A teachers' self-efficacy has an enormous impact on the instructional practices as well as the level of student engagement in the classroom. These two factors shape how students grow in their understanding of the curriculum. According to Tschannen-Moran and Woolfolk Hoy (2001), teacher efficacy is the self-belief that it is within each teacher's own area of control to make judgments and form action plans to make a difference in their own classrooms. Context and subject matter knowledge also impact a teacher's level of teacher efficacy (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). In this study, it is necessary to measure specifically the teachers' mathematics teaching efficacy to determine whether this factor has an influence on the teacher's ability to teach the required mathematics content.

Math teaching efficacy. The Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) developed by Enochs, Smith, and Huinker (2000) sets out to measure a teacher's belief in their own skill in teaching mathematics toward student knowledge of the content. This instrument was adapted from the Science Teaching Efficacy Beliefs Instrument developed by Riggs and Enochs (1990), a widely used scale in science teacher efficacy literature. MTEBI was developed to assess pre-service elementary teachers' efficacy in teaching mathematics. It has emerged from the literature as a reliable and valid instrument for assessing teacher efficacy concerning the teaching of mathematics (Enochs, et. al, 2000). The confirmatory factor analyses provided evidence of construct validity for the scale with an index fit value of 0.919.

The MTEBI consists of two subscales, one subscale measures personal mathematics teaching efficacy (SE), and the second subscale measures mathematics teaching outcome expectancy (OE). MTEBI contains 21 items (Enochs, et. al, 2000). There are 13 items on the SE subscale and 8 items on the MTOE subscale. Scores on the SE scale range from 13 to 65; OE scores range from eight to 40 (Enochs, et. al, 2000). The reliability analysis produced by the Cronbach alpha coefficient of internal consistency was 0.88 for the SE scale and was 0.77 for the OE scale (Enochs, et. al, 2000).

The MTEBI features in numerous research studies. In the study of the Relationship of Mathematics Anxiety of Elementary Preservice Teachers with Mathematics Teacher Efficacy, the MTEBI determined the participants' math teacher efficacy (Swars, Lloyd, Wilson, Wilkins, & Behm, 2005). This study focused on preservice teachers and performed correlations between the participant's level of math anxiety and their level of math teacher efficacy. The survey data indicated that preservice teachers who had stronger beliefs in their own math skills tended to have lower levels of math anxiety. The study found no relationship between a preservice teacher's low beliefs in his or her own math skills and their belief in teaching mathematics.

Kahle (2008) studied how elementary school teachers' mathematical self-efficacy and mathematics teacher self-efficacy related to conceptually and procedurally oriented teaching practices. This study focused on teachers of third, fourth, fifth and sixth grades. The research was a mixed-method study, using the MTEBI survey for math teaching efficacy, a survey of the feelings of the participants' levels of confidence in knowing a list of mathematical topics, and demographic information. She found that positive self-efficacy had a relationship with conceptually oriented teaching. Additionally, a teacher who had high mathematics teaching efficacy on a particular topic of study tended to be conceptually focused on that topic, but when the teacher had a low teaching self-efficacy about a topic, the teacher tended to use procedural practices in the classroom.

Swackhamer, Koeliner, Basile, and Kimbrough (2009) worked with 86 in-service elementary teachers in a mixed-method study. All 86 teachers completed a Science Teaching Belief Instrument before and after completing a content course. The study found that "increasing the level of content knowledge and demonstrating teaching methods appropriate for conveying this knowledge… contributed to an increase in the levels of outcome efficacy" (p. 74). The results of the study also showed that the "outcome efficacy was higher in teachers who had taken four or more math or science content courses." (p. 74)

Swars, Hart, Smith, Smith, and Tolar (2007) studied 103 elementary pre-service teachers who participated in a math pedagogy course. Each participant completed the

Mathematics Teaching Efficacy Beliefs Instrument before and after the course. This study found that there was a significant increase in the participants MTEBI score after the completion of the methods courses.

Aerni (2008) conducted a research study of 115 middle school mathematics teachers. These teachers completed three survey instruments that shared their beliefs about teaching, their beliefs about teaching in an inclusive setting, and their perceptions of participation in graduate mathematics coursework. Not all participants took part in all professional development programs. There were 14 possible professional development activities available. These activities ranged from content and methods courses, presenting and attending the locally hosted math conferences and lesson study groups. This study found through both quantitative and qualitative analysis that there was a positive relationship between the numbers of mathematics professional development activities the teachers participated and the increase in their self-efficacy for teaching in inclusive settings.

Summary

In examining the research that has been completed in the field of mathematics instruction, no studies could be found connecting math teaching/learning experiences, with mathematics content pedagogical knowledge and mathematics teaching efficacy. Surveying the mathematics teaching profile, assessing the mathematics pedagogical knowledge, and determining the values and beliefs about teaching mathematics will allow this researcher to examine the relationship among these constructs.

Chapter 3. Methodology

This chapter will describe the data collection procedures, the instrument used, the data analysis procedures, the limitations, and the ethical safeguards employed in this study. The purpose of this study was to determine whether a relationship exists among three components: mathematics teacher profile, mathematic content pedagogical knowledge, and mathematics teaching efficacy.

Research Questions

1. To what extent are primary grade teachers (a) proficient with third grade pedagogical and content knowledge in mathematics, (b) efficacious in mathematics teaching, and (c) experienced in teaching mathematics?
2. What relationship exists between third grade mathematics pedagogical and content knowledge and
    a) college preparation experiences:
       (1) mathematics major, (2) degree level, (3) endorsement types;
    b) number of years teaching experience:
       (1) primary elementary, (2) upper elementary, and (3) middle school grades;
    c) professional development experiences:

(1) number of post-college math courses taken, (2) completion of the national board certification process, and (3) frequency level of participation in mathematics professional development opportunities?

3. What relationship exists between the level of teacher's mathematics teaching efficacy and
   a) college preparation experiences:
      (1) mathematics major, (2) degree level, (3) endorsement types;
   b) number of years teaching experience:
      (1) primary elementary, (2) upper elementary, and (3) middle school grades;
   c) professional development experiences:
      (1) number of post-college math courses taken, (2) completion of the national board certification process, and (3) frequency level of participation in mathematics professional development opportunities?
4. What relationship exists between the level of teacher's mathematics teaching efficacy and the primary grade teacher's proficiency with third grade mathematics pedagogical and content knowledge?

Data Sample and Collection Procedures

Population and sample size. Virginia is comprised of eight different regions. Each school district resides in one of the eight regions. This research focused on teachers who teach in Virginia and are currently instructing in the primary grades of kindergarten, first, and second. The sample included teachers from school districts that represent the current state population. This sample was identified by working through a state network of district math curriculum coordinators, math curriculum supervisors, and central office administrators that direct and oversee mathematic curriculum personnel. The following calculations were performed to determine the sample size necessary for this research to be generalizable: $\boldsymbol{n} = \boldsymbol{z}^2(\frac{(p)*(1-p)}{c^2})$ was used to calculate the *n* and then $\boldsymbol{ss} = \frac{n}{1+\frac{n}{pop}}$ was used to determine the sample size necessary to generalize findings. To obtain a 95% confidence level 1.96 was used for z. Five tenths was used for the expected frequency factor (p value) and 0.5 was used for the confidence interval (c value). In Table 5, the primary grade teacher population was estimated to be at least 10,000, which calculated an *n* value of 384.16. This research study needed to have a sample size of 370 participants in order for the results to be generalizable across Virginia.

Table 5

Estimated Number of Primary Grade Teachers in Virginia

Grade Level	# of Students (Virginia Department of Education, 2012, September)	# of Estimated Teachers $\frac{\text{\# of Students}}{\text{25 (approx.\# Students per class)}}$
Kindergarten	89,525	3,581
First Grade	95,017	3,800
Second Grade	95,321	3,812
Total	279,876	11,194

Sample. The sample for this study was 207 primary grade teachers. This sample size does not meet the total respondents necessary to generalize these findings to Virginia. Table 6 displays the distribution of respondents. There were 70 kindergarten teachers, 70 first grade teachers, and 67 second grade teachers.

Table 6

Distribution of Respondents across Primary Grades

Grade Taught	Frequency	Percent
K	70	33.8
1	70	33.8
2	67	32.4
Total	207	100.0

It was the intent to have a sampling of all eight Virginia regions. Table 7 displays the data that all eight regions of the state of Virginia were represented and 61 respondents did not report the region in which they teach.

Table 7

Distribution of Respondents Across the Regions of Virginia

Region	Frequency	Percent
Not reported	61	29.5
1	24	11.6
2	36	17.4
3	21	10.1
4	15	7.2
5	22	10.6
6	7	3.4
7	13	6.3
8	8	3.9
Total	207	100.0

Collection procedures. The researcher contacted the math supervisor at the Virginia Department of Education to obtain a listing of all math leadership positions representing every school division. This list provided the region number, the school division name, the name of the person who is the state contact for mathematics curriculum, and each contact's email address. Using this information, contacted each contact person to explain this research study and invite his or her school division to participate. One-hundred and twenty-three school divisions were invited. Twenty-eight school divisions accepted the invitation to participate. Eighty-four school divisions did not reply to the invitation email. After the initial email, three follow-up emails were sent to the school divisions that had not responded.

The researcher conducted follow-up emails with each school division that agreed to participate. The contact person from the school division provided with any policy guidelines or steps to follow in contacting the primary grade teachers. The researcher followed the guidelines that were provided by each school division. For the majority of participating districts (96%) the following steps were taken. Teachers were contacted through an informational email. This email included the background on the survey, an informed consent document (see Appendix B), and directions on how to access the survey. Invitees were also informed that this survey was voluntary, that the respondent would remain anonymous, and the respondent could stop the survey at any time. Willing volunteers completed the survey.

Instrumentation

The survey used for this study had three sections (see Appendix C). The first section targeted data about the participants' mathematics teacher profile information, the second instrument measured Teaching Mathematics Self-Efficacy, and the third instrument collected data on the teachers' mathematical content and pedagogical knowledge.

Math teacher profile. Researchers have concluded that teachers do matter a great deal (Nye, et al., 2004). Differences in teachers account for 12% to 14% of total variability in students' mathematical achievement in each of grades 1, 2, and 3 (Hattie, 2012). Therefore, this study collected data to determine the level of experience of each participant.

Teachers' self-reported information regarding the number of years taught at the various elementary grades. Primary teachers may have experience in grades other than their current assignment. Identifying grade levels at which the teacher had taught provided a clearer picture as to his or her knowledge and expertise level with content and pedagogical knowledge. Other topics included in the teacher experience portion of this survey included college preparation experiences, work experiences and in-service professional development experiences. The focus of the college preparation experiences included the extent of mathematics course work completed, level of college degree, and types of endorsements earned. The work experience portion focused on the number of years teaching at various elementary grade levels. In-service professional development experiences, post-college mathematics coursework, National Board Certification, and frequency of participation in mathematics focused professional development were included.

This portion of the survey was used during statistical analysis to see if any of these factors correlated with mathematics teaching self-efficacy, content knowledge, and/or pedagogical knowledge. These topics are a means of investigating the ways in which selected professional growth opportunities affect a teacher's mathematics teaching efficacy and mathematics content pedagogical knowledge.

Mathematics teaching efficacy beliefs instrument. Teaching efficacy is defined as a teacher's belief in his or her capability for organizing and executing teaching tasks and is necessary for success in accomplishing the appropriate teaching task in a particular situation (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). The Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) developed by Enochs, Smith, and Huinker (2000) measures teachers' "beliefs toward their abilities to teach mathematics for student understanding" (p. 197). Creators of the instrument modeled it after the Science Teaching Efficacy Beliefs Instrument developed by Riggs and Enochs (1990), a widely used scale in science teacher efficacy literature. MTEBI assesses preservice elementary teachers' efficacy in teaching mathematics. It has emerged from the literature as a reliable and valid instrument for assessing teacher efficacy concerning the teaching of mathematics (Enochs, et. al, 2000). The confirmatory factor analyses provided evidence of construct validity for the scale with an index fit value of 0.919.

The Mathematics Teaching Efficacy Belief Instrument (MTEBI) has been used in numerous research studies prior to being used in this study. The populations in those studies were not similar to this study. In order to establish reliability for this population, the Cronbach Alpha for each scale was calculated. The SE scale scored a .76 and the OE scale scored a .78. These Cronbach Alpha scores establish that this instrument was reliable for this study.

This research used the Mathematics Teaching Efficacy Beliefs Instrument to collect participant data on their level of Personal Mathematics Teaching Efficacy (SE) and Mathematics Teaching Outcome Expectancy (OE). The respondents in this study are in-service classroom teachers of grades kindergarten, first and second. To ensure that this instrument and its scales are valid, the research performed a principal component analysis. A scree test determined that there were 2 factors. Table 8 displays how the items loaded. This component matrix displays the factors loading in much the same way that the instrument loaded for Enochs, Smith and Huinker (2000).

Table 8

Component Matrix for MTEBI

	Component	
	SE	OE
SE21	**.693**	-.134
SE17	**.685**	-.101
SE18	**.683**	-.065
SE3	**.670**	-.039
SE19	**.635**	-.272
SE8	**.628**	-.112
SE15	**.596**	-.105
SE11	**.589**	.053
SE20	**.568**	.011
SE16	**.547**	-.282
SE5	**.478**	.098
SE6	**.457**	-.221
SE2	**.386**	.111
OE4	.121	**.605**
OE13	.284	**.579**
OE1	-.026	**.569**
OE12	.312	**.560**
OE7	.098	**.521**
OE14	.239	**.485**
OE10	.179	**.411**
OE9	.072	**.377**

Note: bolded items indicate larger value and component loading

Reliability analysis produced an alpha coefficient of 0.846 for the SE subscale and an alpha coefficient of 0.657 for the OE subscale. Example items that assess the SE subscale include, "I will continually find better ways to teach mathematics" and "Even if

I try very hard, I will not teach mathematics as well as I will most subjects." Example items that assess the OE subscale include, "When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort," and "When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher." Since the research on this scale has concluded that it is valid and reliable, it was used in this research study.

Mathematical knowledge for teaching (MKT) instrument questions. The teacher performance evaluation system in Virginia includes seven standards (Virginia Department of Education, 2011, May). The first standard assesses teacher knowledge, which contains three key elements. The first key element addresses the expectation that a teacher's knowledge needs to incorporate how students learn and implement learning experiences that concentrate on this knowledge. The second element addresses the need for teachers to understand the big ideas of the curriculum that they are required to teach. This includes incorporating appropriate activities to support student learning. The third key element focuses on the teacher knowing meticulously the curriculum standards (Virginia Department of Education, 2011, May).

The National Council of Teachers of Mathematics (NCTM) (2000) published a standards document that outlines the concepts and principals necessary for students learn mathematics in all grade levels. NCTM (2000) defines the learning principle as follows: "students must learn mathematics with understanding, actively building new knowledge from experience and previous knowledge." (p. 2) In addition, for teachers to be proficient "in a complex domain such as mathematics entails the ability to use knowledge flexibly, applying what is learned in one setting appropriately in another" (NCTM, 2000, p. 20). It is important that primary teachers believe that all students in the early grades can learn significant mathematics through planned, well-intentioned activities. A teacher's ability to teach depends on his or her own experience level that the teacher has (Kilpatrick, Swafford, Findell, & ebray, 2001). If a teacher only knows one way to work a problem and has little confidence in the material, it is safe to assume that the teacher will not be able to answer probing questions from the students or be able to use multiple methods to support differentiated learning (Kilpatrick, et al., 2001).

Questions from the bank created by the Learning Mathematics for Teaching Project (LMT) are only available to people trained in using the materials. The LMT project researchers at the University of Michigan facilitate the one-day training. To increase the level of validity and reliability, the LMT project researchers require that the items are always secure and not distributed publicly. As part of the training, participants gain access to all of the field-tested questions, so that instruments can be developed to measure characteristics and content necessary for research projects. The data contained in the following tables comes from the training materials provided as part of the participation in the professional development the LMT research group offers. As the researcher was not trained, collaboration with a trained person occurred so that a valid and reliable instrument was developed. Using the data from this group of respondents, a Cronbach alpha score of .914 was calculated.

The MKT items measure a teacher's level of mathematical content pedagogical knowledge. The work in constructing valid and reliable items to measure this knowledge began with a research project started through work done with the Study of Instructional Improvement project (Rowan, Schilling, Ball, & Miller, 2001). Survey items selected from this MKT database were limited to content that matches the content found in the Virginia Third Grade 2009 Mathematics Standards of Learning. The content is introduced in kindergarten, and is developed in both first and second grades. The topics will include Place Value; Modeling; Algebraic Patterning and Sequencing; Measurement; and Basic Addition, Subtraction, and Multiplication Facts.

Items in the MKT database fall into the categories of either content knowledge (CK) or knowledge of content and students (KCS). From these topics, question selection was based on both CK and KCS. Using the Summary of technical information document, questions were selected using a slope of 0.5 or greater and a majority of items had a level of difficulty between +1 and -1 (Hill & Schilling, 2003). The slope of each item was calculated by dividing item response by test score. The difficulty of each item was calculated through each item's indirect relationship to the p-value. This portion of the survey needed to remain balanced so that the data collected could assess a true measure of content and pedagogical knowledge. Too many easy items or too many difficult items would have produced invalid data. In order to use items from the MKT database, collaboration occurred with an LMT trained researcher.

To select the questions from the bank of Learning Mathematics for Teaching Project (LMT), the first step was to identify Virginia Standards of Learning (SOL) topics that are taught in grades K, 1, 2, and 3 (Virginia Department of Education, 2010d). After analyzing the vertical SOL topics, six LMT topics matched with SOL topics. These included Place Value, Practical Problems, Fractions, Algebraic Patterns, Computation, and Geometry. In Table 9, selected items are categorized by the following: topic, question number, vertical alignment, and type of knowledge.

Table 9

Survey Question Information

Topic	Question Number	Vertical SOL Match	Type of Knowledge
Place Value	1	K.1, 1.1, 2.1, 3.1	CK
Place Value	2	2.7, 3.2	CK
Practical Problems	3	1.6, 2.8, 3.4	CK
Fractions	4	K.5, 1.3, 2.3, 3.3	CK
Fractions	5	K.5, 1.3, 2.3, 3.3	CK
Algebraic Patterns	6	K.16, 1.17, 2.20, 3.19	KCS
Computation	7	K.6, 2.9, 3.6	KCS
Computation	8	1.5, 2.5, 3.5	KCS
Computation	9	3.20	KCS
Geometry	10	K.10, 1.10, 3.10	CK
Geometry	11	K.12, 1.12, 2.16, 3.14	CK
Geometry	12	K.15, 1.16, 3.16	CK

Even though there are only 12 items on this part of the survey, nine questions have multiple parts, with each part having statistical values. In selecting the appropriate items so that the assessment would be in line with the training, items also had to have a slope value of at least 0.5 and most items had to have a level of difficulty between positive one and negative one, per the instructions from the LMT training for developing a valid and reliable survey instrument. Table 10 provides these values for each item.

Table 10

Survey Question Slope and Level of Difficulty

Topic	Question #	Slope	Difficulty
Place Value	1a	0.619	-0.760
Place Value	1b	0.834	-0.406
Place Value	2a	0.569	-0.556
Place Value	2b	0.880	-1.429
Place Value	2c	0.963	0.391
Place Value	2d	0.915	-1.499
Place Value	2e	0.953	-0.161
Practical Problems	3a	0.924	-0.577
Practical Problems	3b	0.884	-0.588
Practical Problems	3c	0.866	-0.340
Fractions	4a	1.053	-1.818
Fractions	4b	0.959	-1.700
Fractions	4c	0.997	-1.650
Fractions	4d	1.031	-2.190
Fractions	5	0.597	-0.771
Algebraic Patterns	6a	0.757	-0.203
Algebraic Patterns	6b	0.454	-0.495
Algebraic Patterns	6c	0.523	0.842
Computation	7a	0.522	0.145
Computation	7b	0.777	-1.365
Computation	8a	0.695	-0.991
Computation	8b	1.327	-0.955
Computation	8c	0.815	0.747
Computation	9a	0.801	0.928
Computation	9b	0.919	-1.490
Computation	9c	0.553	1.637
Geometry	10a	0.535	-0.860
Geometry	10b	1.109	0.683
Geometry	11	1.057	-0.526
Geometry	12	0.508	-0.920

This part of the survey instrument has seven items that measure place value, 3 items that measure practical problems, 5 items that measures fractions, 3 items that measures algebraic patterns, 8 items that measure computation, and four items that measures geometry. There are items 11 items that measures knowledge of content and students (KCS) 19 items that measures content knowledge (CK).

Once the research data was collected, a principal component analysis was performed on this instrument. A Scree test indicated that there was only one factor. All items loaded on the principal component analysis with a .3 value or greater. Even though the design of the instrument intended to denote content knowledge and knowledge of content and student, the items did not load in this fashion. The other classification system used on this instrument distinguished items by topic, to include place value, practical problems, fractions, algebraic patterns, computation, and geometry. Further analysis will focus on the total score that included all items, and analysis does not include any additional scales.

Data Analysis

The researcher collected data using an online survey. The survey was constructed so that each part of the survey would have a numerical value attached to the responses. Part one contained categorical data, part two used a Likert scale, and part three used a numerical rubric analysis with a specific value for each answer.

Data analysis. Each participant's survey responses were placed into Statistical Package for Social Sciences (SPSS), version 20, to calculate descriptive statistics, frequency charts, distributions, and correlations (See Table 11).

Table 11

Data Analysis

Research Question	Data Analysis
1. To what extent are primary grade teachers (a) proficient with third grade pedagogical and content knowledge in mathematics, (b) efficacious in mathematics teaching, and (c) experienced in teaching mathematics?	Descriptive Statistics Frequency
2. What relationship exists between third grade mathematics pedagogical and content knowledge and a. college preparation experiences: (1) mathematics major, (2) degree level, (3) endorsement types; b. number of years teaching experience: (1) primary elementary, (2) upper elementary, and (3) middle school grades; c. professional development experiences: (1) number of post-college math courses taken, (2) completion of the national board certification process, and (3) frequency level of participation in mathematics professional development opportunities?	Correlation Analysis

Research Question	Data Analysis
3. What relationship exists between the level of teachers' mathematics teaching efficacy and a. college preparation experiences: (1) mathematics major, (2) degree level, (3) endorsement types; b. number of years teaching experience: (1) primary elementary, (2) upper elementary, and (3) middle school grades; c. professional development experiences: (1) number of post-college math courses taken, (2) completion of the national board certification process, and (3) frequency level of participation in mathematics professional development opportunities?	Correlation Analysis
4. What relationship exists between the level of teacher's mathematics teaching efficacy and the primary grade teacher's proficiency with third grade mathematics pedagogical and content knowledge?	Correlation Analysis

Limitations

Methodology. Because the researcher conducted the research through the use of a survey instrument, some limitations need to be noted. Surveys require a sample size adequate to make generalizations across the greater population. To ensure that this occurred, invited many more participants than are required for all regions of the state to allow for nonrespondent percentages. Survey's were taken by choice; therefore the use of incentives and reassurance of confidentiality was extremely important.

Data analysis. This study required a minimum of 370 respondents to allow for generalizability to the entire state of Virginia. With only 207 respondents, the study will only provide tentative data for relationships that may exist between defined variables. Respondents completed this survey by personal choice, which limited the study. Many more participants received an invitation to respond than actually completed the survey. The email subject line that invited participants contained the words, "Primary Mathematics Teacher Survey." This title may have discouraged some teachers to participate, since the survey was mathematics-based. What is more, the information that the survey would take approximately 30-minutes may have discouraged some invitees from participating. Fifty participants in the initial respondent set of 257 provided missing data, which excluded them from the study's data analysis set. The survey did not collect the reasons respondents chose not to finish.

Ethical Safeguards

This project was submitted to the College of William and Mary Protection of Human Subjects Committee. It complies with appropriate ethical standards. Participation in the survey was voluntary and individual teachers' responses will not be identifiable. The results were published collectively so individuals are not identifiable. Many participants may be interesed in the final data analysis and this data will be shared with the participants at their request. Executive summaries of the research results will be provided to participating school districts.

Chapter 4. Data Analysis

This study explored variables that are present in the primary teachers' mathematics domain. The variables include (a) mathematics teaching efficacy beliefs measured by the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI), (b) third grade mathematics pedagogical and content knowledge; measured by 12 questions selected from the University of Michigan's pedagogical and content knowledge (PCK) item bank, and (c) teachers' mathematics profiles. The teachers' mathematical profile was composed of three main categories: college preparation experiences, number of years teaching experience, and mathematics with a focus on professional development experiences. Data were collected through an online survey instrument and the Statistical Package for the Social Sciences (SPSS) was used to analyze the data and to determine whether there were any significant relationships among the variables. This chapter reports the results of these analyses.

Analysis of Data Pertaining to Research Question 1

1. Research Question 1: *To what extent are primary grade teachers (a) proficient with third grade pedagogical and content knowledge in mathematics, (b) efficacious in mathematics teaching, and (c) experienced in teaching mathematics?*

Mathematic pedagogical knowledge. Part of the research analysis for the Mathematical Knowledge for Teaching (MKT) measure required that all analysis be conducted at the group level not at the individual respondent level. The MKT also required a minimum N of 60 so that the data analyses would be reliable. Since N = 207, and all 3 of the grade groupings met the required threshold, the analysis was performed on the entire group and at each primary grade level. Table 12 displays the data at the whole group level. The minimum score was 1 correct and the maximum score was a 28. The mean score was 14.53 with a standard deviation was 7.244. This means that the majority of respondents earned between 7 and 21 questions correctly. To answer 70% of the questions correctly, a respondent needed to answer a 21 questions correctly.

Table 12

Respondent Data on the Pedagogical Content Knowledge

	N	Min	Max	Mean	SD	Variance	Skewness	SE	Kurtosis	SE
PCK Score	207	1	28	14.53	7.244	52.474	-0.541	0.169	-0.729	0.337

Table 13 summarizes the pedagogical and content knowledge data by respondents' grade level. On the total assessment PCK, kindergarten teacher respondents answered 1 to 24 questions correctly, the first grade teacher respondents' total scores ranged from 1 to 28 correct answers, second grade teacher respondents' scores ranged from 1 to 27 questions answered correctly.

Table 13

Respondent PCK, Score Distribution grouped by Grade

Grade	N	Min	Max	Mean	SD
Kindergarten	70	1	24	13.57	6.986
First Grade	70	1	28	14.90	6.976
Second Grade	67	1	27	15.13	7.771

Following this analysis, the data were grouped into three categories. The following categories resulted: low performance (0-13), moderate performance (14-19), and high performance (20-30). Table 14 displays the percent of respondent performance by grade and total. Only 28.0 percent of the total respondent sample scored at the high performance level, with grade two teachers slightly above this percent (32.8) and kindergarten teachers were at 5.1 percentage points below.

Table 14

Percent of Performance Level on Pedagogical Content Knowledge (PCK) by Grade

	Grade			Total
	K	1	2	
Performance Level	(n=70)	(n=70)	(n=67)	(n=207)
PCK				
Low	41.4	34.3	32.8	36.2
Moderate	35.7	37.1	34.3	35.7
High	22.9	28.6	32.8	28.0

Notes: Low (0-13); Moderate (14-19); High (20-30)

Respondents' scores were low on the math pedagogy and content questions. Knowing that the questions were targeted to a third grade curriculum, these results are lower than expected from highly qualified PK3 endorsed teachers.

Mathematics teaching efficacy belief instrument. MTEBI collected data regarding the primary teachers' beliefs about student outcome expectancy (OE), and personal mathematics teaching efficacy (SE). Table 15 summarizes data concerning respondents' responses to these areas of efficacy. The MTEBI employs a 5-point Likert scale. Eight questions were reversed-scored so that the values would be consistent with the positively worded items. There was 21 items with a maximum score of 105 points. Student outcome expectancy (OE) contained eight items with a total maximum score of 40 points; personal mathematics teaching efficacy (SE) contained 13 items for a total maximum score of 65 points. Table 15 displays the respondents' mean score of 82.4. As skewness and kurtosis were relatively small, a relatively normal curve resulted. Respondents' SE scores had a mean of 53.63 and a SD of 5.302. The skewness and kurtosis were relatively small, producing a relatively normal curve. Respondent scores for OE had a mean of 26.74 with an SD of 2.881. The skewness and kurtosis were relatively small, producing a relatively normal curve.

Table 15

Respondent results for the Mathematics Teaching Efficacy Belief Instrument

	N	Min	Max	Mean	SD	Variance	Skewness		Kurtosis	
							Statistic	SE	Statistic	SE
MTEBI	207	62	97	82.4	6.538	42.745	-.047	.169	.023	.337
SE	207	41	65	53.63	5.302	28.109	.090	.169	-.299	.337
OE	207	19	34	26.74	2.881	8.301	-.225	.169	-.461	.337

Table 16 displays the MTEBI, OE, and SE efficacy scores by grade level. All of the grade level groups had similar minimum, maximum, mean, and SD for each scale.

Table 16

Respondent MTEBI, SE and OE Score Distribution grouped by Grade

		N	Min	Max	Mean	SD
MTEBI						
	Kindergarten	70	71	97	81.20	6.310
	First Grade	70	65	96	83.00	6.418
	Second Grade	67	62	96	83.01	6.815
SE						
	Kindergarten	70	45	64	53.49	5.110
	First Grade	70	41	65	53.67	5.735
	Second Grade	67	41	64	53.73	5.101
OE						
	Kindergarten	70	20	34	25.80	2.897
	First Grade	70	20	32	27.31	2.557
	Second Grade	67	19	32	27.12	2.977

Note: SE = Personal Mathematics Teaching efficacy Belief; OE =Student Outcome Expectancy.

Following this analysis, the data for each scale were grouped into three categories. The intent was to have similar sized respondent categories by efficacy level. For the MTEBI as a whole, the following categories resulted: low efficacy (61-80), moderate efficacy (81-85), and high efficacy (86-97). For the SE scale, the following categories resulted: low efficacy (13-52), moderate efficacy (53-55), and high efficacy (58-65). For the OE scale as a whole, the following categories resulted: low efficacy (8-25), moderate efficacy (26-28), and high efficacy (29-34).

Table 17 displays percent of performance level by grade and total. Kindergarten has the greatest percent of low efficacy in all three scales, with MTEBI (58.6), SE (58.6), and OE (45.7). First grade respondents demonstrated strength (38.6%) in OE. Second grade was closely split across all efficacy level categories in all three scales.

Table 17
Percent of Performance Level on Mathematics Teaching Efficacy and Belief Instrument (MTEBI) and Scales by Grade and Total

	Grade			Total
Efficacy level	K (n=70)	First (n=70)	Second (n=67)	(n=207)
MTEBI				
Low	58.6	32.9	32.8	41.5
Moderate	17.1	37.1	34.3	29.5
High	24.3	30.0	32.8	29.0
SE				
Low	58.6	35.7	46.3	46.9
Moderate	12.9	28.6	22.4	21.3
High	28.6	35.7	31.3	31.9
OE				
Low	45.7	22.9	31.3	33.3
Moderate	37.1	38.6	31.3	35.7
High	17.1	38.6	37.3	30.9

Note: SE = Personal Mathematics Teaching efficacy Belief; OE =Student Outcome Expectancy. MTEBI: Low (61-80); Moderate (81-85); High (86-105); SE: Low (13-52); Moderate (53-55); High (56-65). OE: Low (8-25); Moderate (26-28); High (29-40)

Math teaching efficacy was in the range of low to moderate for all grade level respondents. Kindergarten teachers' math teaching efficacy was the lowest of all groups. But it is interesting to note that the kindergarten group did not have the lowest score and it did have the highest score. First and second grade had similar scores, and similar standard deviations.

Mathematics teacher profile. As part of the mathematics teachers' profile, there were three variables of focus: college preparation experience, years of work experience, and in-job professional development experiences.

College preparation experience. For the collection of data regarding college preparation experiences, respondents answered questions regarding the types of endorsements they had earned, the highest degree that they had completed, and the extent to which their degrees were math focused. Table 18 summarizes all college preparation data by grade level and total group

All respondents earned one of the following endorsement types: pre-kindergarten to grade three (PK3), pre-kindergarten to grade six (PK6), pre-kindergarten to grade eight (PK8), or other. As reported in Table 18, most respondents (46.4%) reported that they held a PK6 endorsement. This was a similar percent in all grade levels. Respondents could choose multiple endorsements. As only five respondents selected an additional endorsement area, accounting for less than three percent of the total respondent population, data was not significant, and therefore not reported.

Table 18 shows that most respondents (98.1%) did not focus in mathematics while in college. Only four (1.9%) minored in mathematics, and zero respondents majored in mathematics. This percent was consistent across all grade levels. Although zero is a significant number to reflect upon, the analysis of the remaining research questions did not employ this data.

Table 18 displays a majority (49.8%) of respondents had earned a master's degree. Twenty-six percent had earned a bachelor's degree, and 24.2% of the respondents had earned a bachelor's degree plus additional graduate coursework. The highest degree percent for kindergarten was significantly different from the other two grade levels. Kindergarten had 37.1 percent bachelors as the highest where both first (54.3%) and second grade teachers (61.2%) had master's degrees as the highest degree attained. No respondents reported having earned a doctorate.

Table 18

Distribution of teacher endorsement

	Grade			Total
College Preparation	K (n=70)	First (n=70)	Second (n=67)	(n=207)
Endorsement Type				
Other	18.6	17.1	14.9	16.9
PK-3	22.9	20.0	19.4	20.8
PK-6	41.4	47.1	50.7	46.4
PK-8	17.1	15.7	14.9	15.9
Highest Degree				
Bachelor	37.1	25.7	14.9	26.1
Bachelor +	28.6	20.0	23.9	24.2
Masters	34.3	54.3	61.2	49.8
Doctorate	–	–	–	–
College Math Focus				
Neither	97.1	100.0	98.5	98.6
Minor	2.9	–	1.5	1.4
Major	–	–	–	–

Notes: No respondents selected (–)

Work experience. Table 19 summarizes work experience. These data include the mean, standard deviation, skewness and kurtosis information. For grade level teaching experience in grades K, 1, and 2, the mean was 12.68 with a standard deviation of 8.933. The skewness (0.854) and kurtosis (0.049) indicate that the data is close to a normal distribution. For the grade level experience in grades 3, 4, and 5, the mean was 3.71 years with a standard deviation of 4.764. The positive skewness (2.313) indicates that there were a greater number of smaller values, and the positive kurtosis (6.171) indicated that the values were more peaked than flat. For the grade level teaching experience in grades 6, 7, and 8, the mean was 1.08, with a standard deviation of 0.805. An even smaller variance and a larger positive skewness (4.974) along with an extremely large kurtosis value (33.926), signified that these data were not normal in anyway and indicated a need to proceed cautiously with the analysis.

Table 19

Distribution of Work Experience

Grade levels	N	Min	Max	Mean	SD	Variance	Skewness	SE	Kurtosis	SE
K, 1, 2	207	2	40	12.68	8.933	79.793	.854	.169	.049	.337
3, 4, 5	207	0	30	3.71	4.764	22.694	2.313	.169	6.171	.337
6, 7, 8	207	0	8	1.08	.805	.649	4.974	.169	33.926	.337

Following this analysis, the data were grouped into four categories. The intent was to have similar sized respondent categories by number of years of experience within each section. This disaggregated look at the data was to see if any patterns emerged in regards to grade level respondents' work experiences at the varying grade bands. Work experiences in grades K, first, and second were categorized as follows: (1-6 years), (7-11 years), (12-18 years), and (19-39 years). Data regarding work experience at third, fourth, and fifth grade levels resulted in two categories, (0) and (1-11). Data obtained regarding work experience at the sixth, seventh, and eighth grade levels resulted in two categories, (0) and (1-7). Data for years teaching experience resulted in four categories, (1-9), (10-14), (15-22), and (23-40).

Table 20 displays percent of number of years teaching at the various grade bands by grade and total. Kindergarten teacher respondents had the greatest percent (32.9%) of teachers in the most number of years work experience category (19-39 years). First grade teacher respondents had the greatest percent (31.4%) of respondents in the least experience category (1-6 years), but the largest percent (70%) of respondents teaching in the Grade third, fourth, fifth group. Second grade teacher respondents had the smallest percent (9%) of respondents in the most experiences category (19-39 years).

Table 20

Percent of Years Work Experience Groupings by Grade and Total

	Grade			Total
	K	1	2	
Years of Experience	(n=70)	(n=70)	(n=67)	(n=207)
Grades K,1,2				
1-6	22.9	31.4	29.9	28.0
7-11	17.1	25.7	34.3	25.6
12-18	27.1	15.1	26.9	23.2
19-39	32.9	27.1	9.0	23.2
Grades 3,4,5				
0	57.1	70.0	44.8	57.5
1-11	42.9	30.0	55.2	42.5
Grades 6,7,8				
0	91.4	95.7	91.0	92.8
1-7	8.6	4.3	9.0	7.2
Total Years				
1-9	20.0	38.6	25.4	28.0
10-14	22.9	18.6	29.9	23.7
15-22	30.0	17.1	26.9	24.6
22-40	27.1	25.7	17.9	23.7

Professional development experiences. Respondents reported data concerning their professional development experiences. The survey questions asked (a) the number of post-college mathematics courses they had successfully completed, (b) whether they had completed the National Board Certification of Teachers process, and (c) the frequency with which they had participated in professional learning opportunities focused on mathematics over the past five years.

Table 21 displays respondent answers to the questions concerning math professional learning experiences. Approximately 50% of the respondents have completed some post-graduate math course and 50% have not completed any post-graduate math courses. This statistic was similar across all grade levels.

Respondents indicated the frequency with which they had participated in math focused professional development opportunities. As noted in Table 21, 49.3% of the respondents occasionally participated in math focused professional development activities. The percent found at each grade level was similar.

Table 21 also summarized the number of respondents who had completed the National Board Certification of Teachers process. Most of the respondents (89.9%) had not completed this process; only 10.1% had completed it. This was similar across the grade level data as well. Since there were so few identified Nationally Board Certified teachers, the remaining research analyses did not incorporate these data.

Table 21

Percent of Participation in Math Professional Learning (PL) Experiences by Grade Level and Total

	Grade			Total
	K	1	2	
Math PL	(n=70)	(n=70)	(n=67)	(n=207)
# of Post Grad Math Courses				
0	50	51.4	46.3	49.3
1-12	50	48.6	53.7	50.7
Professional Learning				
Never	4.3	8.6	6.0	6.3
Seldom	21.4	28.6	20.9	23.7
Occasionally	55.7	41.4	50.7	49.3
Frequently	18.6	21.4	22.4	20.8
NBTC				
No	92.9	90.0	86.6	89.9
Yes	7.1	10.0	13.4	10.1

Note: NBTC is National Board Teacher Certification

These descriptive statistics helped identify variables that were either meaningful or could be eliminated from the search for correlations in addressing the remaining research questions. When a statistically significant correlation was discovered, further analysis using the grade level subgroups followed in order to determine whether there were additional statistically significant findings. For each mathematical teaching profile, questions identified subgroups for use in supporting the analysis of data related to the remaining research questions.

Analysis of Data Pertaining to Research Question 2

Research Question 2: *What relationship exists between third grade mathematics pedagogical and content knowledge (PCK) and*

a) college preparation experiences:

(1) mathematics major, (2) degree level, (3) endorsement types;

b) number of years teaching experience:

(1) primary elementary, (2) upper elementary, and (3) middle school grades;

c) professional development experiences:

(1) number post-college math courses taken, (2) completion of the national board certification process, and (3) frequency level of participation in mathematics professional development opportunities?

To answer this question effectively, Spearman rho correlation tests and chi-square tests for independence were used. These tests allowed the use of SPSS to discover relationships or the absence of relationships.

Correlation between college preparation and mathematics teaching knowledge. Table 22 defines the variable sets and categories used in this analysis. The college preparation experience originally included math major, minor or neither. Since the descriptive statistics found only 1.9% of respondents' reported completion of a major or minor in mathematics as part of their course work, these data were omitted from further investigation.

The data for both variables are in ranked groups, making Spearman rho an appropriate statistics test to run to determine whether a relationship exists between college preparation and highest college degree. In Table 22, pedagogy and content score and highest college degree were significantly correlated, $\rho=.143$, $p<.05$ using a 2-tailed Spearman rho test.

Table 22

Spearman rho Correlation Table of Pedagogy and Content Knowledge (PCK) Performance Level and Highest Degree

Measure	PCK
1. Highest Degree Earned	
Correlation Coefficient	.143*
Sig. (2-tailed)	.039
N	207

Note: Correlation is significant at the 0.05 level (2-tailed).

To determine whether there is a relationship between the PCK score and the type of endorsement, a chi-square of independence test was used. As can be seen by the frequencies cross tabulated in Table 23 and Pearson Chi-Square results in Table 24, PCK performance and teaching endorsement type are independent, X^2 (6, N = 207) = 4.712, $p < .05$. Cramer's V supports this finding with a .107 value. The respondent's PCK score is not correlated to the type of endorsement.

Table 23

Cross tabulation of PCK and Endorsement type

	Endorsement Type				Total
PCK Performance	Other	PK3	PK6	PK8	
Low					
Count	11	17	38	9	75
Expected Count	12.7	15.6	34.8	12.0	75.0
Moderate					
Count	12	18	32	12	74
Expected Count	12.5	15.4	34.3	11.8	74.0
High					
Count	12	8	26	12	58
Expected Count	9.8	12.0	26.9	9.2	58.0
Total					
Count	35	43	96	33	207
Expected Count	35.0	43.0	96.0	33.0	207.0

Table 24

Pearson Chi-Square Test Results for PCK Performance and Endorsement Type

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.712[a]	6	.581
Likelihood Ratio	4.841	6	.564
Linear-by-Linear Association	.099	1	.752
N of Valid Cases	207		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.25.

Correlation between work experience and mathematics teaching knowledge. The work experience survey originally included a question asking whether respondents had taught in grades six, seven, and eight. Since the descriptive statistics found less than 10% of respondents reported they had taught in grades six, seven and eight, data obtained were omitted from further investigation. Data collected for years worked in K, 1, and 2, 3, 4, and 5, as well as total years of experience, was used in this analysis. Both PCK performance and work experience are variables that are in ranked groups. Spearman rho correlations were calculated. As displayed in Table 25, there were no significant correlations between PCK score and K, 1, 2, grade level work experience, PCK score and 3, 4, 5, grade level work experience, and PCK score and total years of teaching experience.

Table 25

Spearman rho Correlation Table of Pedagogy and Content Knowledge (PCK) Performance Level and Work Experience

Measure	K12#	345##	TTLY###
PCK Level			
Correlation Coefficient	-0.14	.074	.072
Sig. (2-tailed)	.845	.288	.305
N	207	207	207

Note: K12# = Years Teaching in Grades K, 1, and 2; 345## = Years Teaching in Grades 3, 4, and 5; TTLY###=Total Years in Teaching

Correlation between professional development experiences and mathematics teaching knowledge. The math professional learning experiences survey originally included a question asking whether respondents had completed the National Board Certification process. Since the descriptive statistics found only 10% of respondents reported they had completed the process, data obtained were omitted from further analyses.

As displayed in Table 26, there is a significant relationship between respondents' PCK Level and frequency of participation in math professional learning (FMPL). Teachers reported how frequently they participated in math professional learning which had a statistically significant relationship with their level of PCK activities. There was no significant relationship between PCK level and respondents' participation in post-graduate math courses (PGMC).

Table 26

Spearman rho Correlation Table of Pedagogy and Content Knowledge (PCK) Performance Level and Math Professional Learning Experiences

Measure	PGMC#	FMPL##
PCK Level		
Correlation Coefficient	.102	.162*
Sig. (2-tailed)	.142	.020
N	207	207

Note: PGMC #= # of Post Graduate Math Courses;
FMPL## = Frequency of Math Professional Learning

Analysis of Data Pertaining to Research Question 3

Research Question 3: *What relationship exists between the level of teacher's mathematics teaching efficacy and*

a) college preparation experiences:

(1) mathematics major, (2) degree level, (3) endorsement types;

b) number of years teaching experience:

(1) primary elementary, (2) upper elementary, and (3) middle school grades;

c) professional development experiences:

(1) number of post-college math courses taken, (2) completion of the national board certification process, and (3) frequency level of participation in mathematics professional development opportunities?

To answer this question effectively, Spearman rho correlation tests and chi-square tests for independence were used. These tests allowed for the use of SPSS to discover relationships or the absence of relationships.

Correlation between college preparation and math teaching efficacy. The college preparation experience originally included math major, minor or neither. Since the descriptive statistics found only 98.3% of respondents' reported completing neither major nor minor in mathematics as part of their course work, these data were omitted from further analyses. Table 27 displays the Spearman correlation values for MTEB Level and highest degree earned. There are no significant relationships found between mathematics teaching efficacy beliefs, SE or OE and highest degree earned.

Table 27

Spearman rho Correlation Table of Mathematics Teaching Efficacy Belief (MTEB) Level and Highest Degree

Measure	MTEB	SE	OE
Highest Degree Earned			
Correlation Coefficient	.093	.027	.080
Sig. (2-tailed)	.182	.806	.255
N	207	207	207

To determine whether there is a relationship between the MTEB level and the type of endorsement, a chi-square of independence test was employed. As can be seen by the frequencies cross tabulated in Table 28 and Pearson Chi-Square results in Table 29

MTEB performance and teaching endorsement type are independent, X^2 (6, N = 207) = 13.077, $p < .05$. Cramer's V supports this finding with a .178 value. There was no relationship found between MTEB and the highest degree earned by the respondent.

Table 28

Cross tabulation of MTEB Level and Endorsement type

		Endorsement Type			Total
Performance	Other	PK3	PK6	PK8	
Low					
Count	17	23	39	7	86
Expected Count	14.5	17.9	39.9	13.7	86.0
Moderate					
Count	7	12	32	10	61
Expected Count	10.3	12.7	28.3	9.7	81
High					
Count	11	8	25	16	60
Expected Count	10.1	12.5	27.8	9.6	60.0
Total					
Count	35	43	96	33	207
Expected Count	35.0	43.0	96.0	33.0	207.0

Table 29

Pearson Chi-Square Test Results for MTEBI Performance and Endorsement Type

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.077	6	.042
Likelihood Ratio	13.281	6	.039
Linear-by-Linear Association	5.252	1	.022
N of Valid Cases	207		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.57.

To determine whether there is a relationship between the SE scale performance level and the type of endorsement, a chi-square of independence test was employed. As can be seen by the frequencies cross tabulated in Table 30 and Pearson Chi-Square results in Table 31, SE scale performance and teaching endorsement type are independent, X^2 (6, N = 207) = 4.069, $p < .05$. Cramer's V supports this finding with a .106 value. There was no relationship found between SE and the highest degree earned by the respondent

Table 30

Cross tabulation of SE Level and Endorsement type

	Endorsement Type				Total
Performance	Other	PK3	PK6	PK8	
Low					
Count	14	24	47	12	97
Expected Count	16.4	20.1	45.0	15.5	97.0
Moderate					
Count	9	9	19	7	44
Expected Count	7.4	9.1	20.4	7.0	44.0
High					
Count	12	10	30	14	66
Expected Count	11.2	13.7	30.6	10.5	66.0
Total					
Count	35	43	96	33	207
Expected Count	35.0	43.0	96.0	33.0	207

Table 31

Pearson Chi-Square Test Results for SE Level and Endorsement Type

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.069	6	.595
Likelihood Ratio	4.625	6	.593
Linear-by-Linear Association	.452	1	.501
N of Valid Cases	207		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.01.

To determine whether there is a relationship between the OE scale performance level and the type of endorsement, a chi-square of independence test was employed. As can be seen by the frequencies cross tabulated in Table 32 and Pearson Chi-Square results in Table 33 OE scale performance and teaching endorsement type are independent, X^2 (6, N = 207) = .870, $p < .05$. Cramer's V supports this finding with a .046 value. There was no relationship found between OE and the highest degree earned by the respondent

Table 32

Cross tabulation of OE Level and Endorsement type

	Endorsement Type				Total
Performance	Other	PK3	PK6	PK8	
Low					
Count	11	16	32	10	69
Expected Count	11.7	14.3	32.0	11.0	69.0
Moderate					
Count	13	15	35	11	74
Expected Count	10.8	13.3	29.7	10.2	64.0
High					
Count	11	12	29	12	64
Expected Count	10.8	13.3	29.7	10.2	64.0
Total					
Count	35	43	96	33	207
Expected Count	35.0	43.0	96.0	33.0	207.0

Table 33

Pearson Chi-Square Test Results for OE Level and Endorsement Type

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.870	6	.990
Likelihood Ratio	.864	6	.990
Linear-by-Linear Association	.139	1	.710
N of Valid Cases	207		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 10.20.

Correlation between work experience and math teaching efficacy. The work experiences originally included number of years teaching in grades 6, 7, and 8. Since the descriptive statistics found only 7% of respondents reported teaching in grades 6, 7, and 8, data obtained were omitted from further study. The variables of MTEB, SE, OE and work experience are variables that are in ranked groups. Spearman rho correlations were calculated. As displayed in Table 34, there were no significant correlations between these variables.

Table 34

Spearman rho Correlation Table of Mathematics Teaching Efficacy Belief (MTEB) Level and Work Experience

Measure	K12#	345##	TTLY###
MTEB			
Correlation Coefficient	-.040	.074	.065
Sig. (2-tailed)	.568	.288	.349
N	207	207	207
SE			
Correlation Coefficient	.014	.050	.079
Sig. (2-tailed)	.842	.479	.255
N	207	207	207
OE			
Correlation Coefficient	-.039	.098	.053
Sig. (2-tailed)	.577	.159	.449
N	207	207	207

Note: K12# = Years Teaching in Grades K, 1, and 2; 345## = Years Teaching in Grades 3, 4, and 5; TTLY###=Total Years in Teaching

Correlation between professional development experiences and math teaching efficacy. The math professional learning experiences originally included a question asking if the respondents had completed the National Board Certification process. Since the descriptive statistics found only 10% of respondents reported they had completed the process, data relating to this variable were omitted from further consideration. As displayed in Table 35, two significant correlations surfaced. MTEB and frequency of math professional learning (FMPL) with a correlation coefficient of .191 was significant to the $p<.01$ level. SE and frequency of math professional learning with a correlation coefficient of .262 was significant at the $p<.01$ level. There were no significant correlations between the efficacy variables and the number of mathematics courses completed (PGMC).

Table 35

Spearman rho Correlation Table of Mathematics Teaching Efficacy Belief (MTEB) Level and Math Professional Learning

Measure	NPGMC#	FMPL##
MTEBI		
Correlation Coefficient	.106	.191**
Sig. (2-tailed)	.127	.006
N	207	207
SE		
Correlation Coefficient	.110	.262**
Sig. (2-tailed)	.113	.000
N	207	207
OE		
Correlation Coefficient	.102	.083
Sig. (2-tailed)	.142	.236
N	207	207

Note: NPGMC# = # of Post Graduate Math Courses; FMPL## = Frequency of Math Professional Learning **$p<0.01$

Analysis of Data Pertaining to Research Question 4

Research Question 4: *What relationship exists between the level of the respondents' mathematics teaching efficacy beliefs and the proficiency level of the mathematics pedagogical and content knowledge?*

This research question required a correlation between MTEB and PCK, SE and PCK and OE and PCK. Since these variables are in ranked groupings, a Spearman rho Correlation was calculated. Table 36 displays a statistically significant relationship between PCK and MTEBI. There was no statistically significant relationship between PCK and the other two variables (SE and OE).

Table 36

Spearman rho Correlation Table of MTEBI, SE, OE, and PCK

Measure	MTEB	SE	OE
PCK			
Correlation Coefficient	.138*	.009	.123
Sig. (2-tailed)	.048	.900	.076
N	207	207	207

Note: * Correlation is significant at the 0.05 level (2-tailed).

Summary

This chapter has provided data that needs deeper examination. Table 37 provides a quick overview of the relationships. Five statistically significant relationships are the focus in chapter five.

Table 37

Relationships Uncovered for Research Questions 2, 3, and 4

Relationship		Test	P	sig
PCK				
	Degree Level	Spearman rho	.143*	.039
	Endorsement Type	Chi-square	4.712	.581
	K,1,2 Work Experience	Spearman rho	-.014	.845
	3,4,5 Work Experience	Spearman rho	.074	.288
	Total Work Experience	Spearman rho	.072	.305
	Frequency of Math Prof Learn	Spearman rho	.162*	.020
	# of Post Grad Math Courses	Spearman rho	.102	.142
MTEB				
	Degree Level	Spearman rho	.093	.182
	Endorsement Type	Chi-square	13.077	.042
	K,1,2 Work Experience	Spearman rho	-.040	.568
	3,4,5 Work Experience	Spearman rho	.074	.288
	Total Work Experience	Spearman rho	.065	.349
	Frequency of Math Prof Learn	Spearman rho	.191**	.006
	# of Post Grad Math Courses	Spearman rho	.106	.127
	PCK	Spearman rho	.138*	.048
SE				
	Degree Level	Spearman rho	.027	.806
	Endorsement Type	Chi-square	4.069	.595
	K,1,2 Work Experience	Spearman rho	.014	.842
	3,4,5 Work Experience	Spearman rho	.050	.479
	Total Work Experience	Spearman rho	.079	.255
	Frequency of Math Prof Learn	Spearman rho	.262**	.000
	# of Post Grad Math Courses	Spearman rho	.110	.113
	PCK	Spearman rho	.009	.900
OE				
	Degree Level	Spearman rho	.080	.255
	Endorsement Type	Chi-square	.870	.990
	K,1,2 Work Experience	Spearman rho	-.039	.577
	3,4,5 Work Experience	Spearman rho	.098	.159
	Total Work Experience	Spearman rho	.053	.449
	Frequency of Math Prof Learn	Spearman	.083	.236
	# of Post Grad Math Courses	Spearman rho	.102	.142
	PCK	Spearman rho	.123	.076

Note: * indicates significance to the .05 level.
** indicates significance to the .01 level.

Chapter 5. Summary, Discussion, Recommendations

Chapter 4 summarized data obtained from this study. Chapter 5 consists of an overarching summary of the study, limitations, discussion of the findings, implications for practice, recommendations for further research, and conclusions. Due to the investigatory nature of this study, many of its findings suggest the need for further research.

Summary of the Study

In present-day education, educational leaders must make decisions by analyzing relevant data. At the national level, the subjects of mathematics and reading attract a great deal of attention. Before the introduction of *No Child Left Behind*, most elementary educational research focused on reading. The Google Scholar search engine produced 36,500,000 results for "primary math research" in .3 seconds, compared to 277,000,000 results in .28 seconds for "primary reading research" (Google Scholar, 2013). This suggests that there is a great deal of research focused on how students learn and teachers teach the skills necessary for reading. The introduction of *No Child Left Behind* legislation has drawn attention to mathematics but comparatively speaking, it currently has generated only a small amount of research data. This study has taken a small step to reveal a problem that currently exists in the primary grade level education. This data can guide school administrators, district leaders, college directors, and state legislators when making decisions related to mathematics education in the primary grades.

Some research exists for grade levels that have state required assessments. With no state or national data regarding primary grade students for mathematics, it is difficult to find research data sufficient to provide direction and guidance. Even though student testing begins at grade three in Virginia, the primary grade teacher plays a critical role in assisting students to develop an understanding of mathematics concepts upon which to build (National Association of Education of Young Children; National Council of Teachers of Mathematics, 2002). The primary grade teachers lay the cornerstones on which future mathematics learning is built. It is important to see what variables influence mathematics teaching skills and levels of math teaching efficacy so that district and school leaders support teacher improvement to meet the required mathematics curriculum.

Discussion of the Results

Key Findings. From the data collected in research question 1, three anticipated results emerged. First, the data confirmed a suspicion: not one of the 207 respondents was a math major in college. This finding alone should give us pause. In the state of Virginia, all elementary majors must first declare a major in a field outside of education. They complete their education endorsement coursework after completion of a majority of their coursework in their declared major (Virginia Department of Education, 2011). This lack of mathematics course work might be one of the causes for the low scores on the mathematics teaching knowledge. Would it make a difference if elementary education candidates were required to complete specified mathematics courses?

Second, respondents scored low on mathematics teaching knowledge. The respondents' PCK scores show that only 16.5% could correctly answer a minimum of 21 questions (70%). This confirms that many primary-grade teachers struggle with the third grade pedagogy and content knowledge that they should be preparing their students to learn. It would appear that math pedagogy and content knowledge requires additional focus.

Third, the MTEBI scores revealed that many teachers doubt their ability to change how they teach mathematics in the classroom. The MTEBI contains 21 items, so the lowest score a respondent can earn would be a 21 and the highest 105. The Lickert scale had five points, with 1 equaling Strongy Disagree, 2 = Disagree, 3 = Uncertain, 4 = Agree, and 5 = Strongly Agree. If a respondent's total was a 63, then the respondent's choices hovered around uncertain on the Lickert scale. A teacher with strong teaching beliefs in teaching mathematics and student outcomes would need to score closer to 84 points. The highest efficacy score recorded on this survey was 97. Kindergarten had the greatest percent of respondents score in the low efficacy level. The high efficacy group had a score of 86 or higher, which means that 71% of all respondents scored lower than an 86 on the intrument. Based on the research concerning efficacy, the more positive a teacher's beliefs are about teaching, the greater the teacher's effect on student achievement (Tschannen-Moran & Woolfolk Hoy, 2001). Knowing this research data, it is important that teachers have a high level of math teaching efficacy. The lack of efficaciousness is troublesome and additional research needs to be conducted to determine how to increase mathematics teaching efficacy for primary grade teachers.

A closer look at the two scales uncovers some additional information. The respondents scored higher on the Student Outcome Expectancy (OE) scales than on the Personal Mathematics Teaching Efficacy Belief (SE). Forty-six percent of respondents had an SE score in the low efficacy level (13-52). Kindergarten teachers had 58% of the 70 teachers in the low level of efficacy for the SE. Grade two teachers had 46% of the respondesnt in the low efficacy level for SE. With low performance on the PCK instrument and low efficacy levels on the MTEBI, some concerns surface concerning how to better support the primary grade teachers.

Additional Findings. Research question four yields an intriguing result. As stated earlier, research on teacher efficacy reveals that the higher a teacher's teaching efficacy, the greater the effect the teacher will have on student achievement (Tschannen-Moran & Woolfolk Hoy, 2001). Since the data on math teaching efficacy data showed that respondents' efficacy levels were low and the respondents' PCK performance levels were low, it was found that the correlation between MTEB and PCK would be significant at the .05 level. With the connection of teacher math teaching efficacy and math pedagocial and content knowledge, focusing on one of these teaching components may help increase the teacher's effectiveness in the classroom.

MTEB had one additional significant relationship with frequency of participation in mathematics professional learning opportunities (ρ=.191, $p<0.01$). SE, a subscale of the MTEBI, had a significant relationship with frequency of math professional learning as well (ρ =.262, $p<0.01$). However, OE, the other scale, did not demonstrate a significant relationship. It is curious that math professional learning had a significant relationship with the overall math teaching efficacy level and the personal math teaching efficacy level. Math professional learning should bolster the confidence of a teacher in teaching mathematics. Since these two variables have a statistically significant relationship, a deeper look at the formats and types of professional learning would be the next logical step.

PCK had significant relationships with two other variables besides MTEBI. One significant relationship was found with the level of college degree attained that respondents reported (ρ=.143, $p<0.05$). It would make sense that a teacher that had taken post graduate math course would have a stronger understanding of the content knowledge at the third grade level. The other significant relationship existed with frequency of mathematics professional development ((ρ=.162, $p<0.05$). This too makes sense. Teachers participating in mathematics professional learning opportunities would increase their content and pedagogical knowledge. It would be interesting to learn more about the types of professional learning experiences the respondents attended. From these data, the sheer fact of attending professional development on an ongoing basis has some relationship with the level of pedagogy and content knowledge necessary for a primary grade teacher.

It is interesting to find that two variables showed no significant relationship with PCK or MTEB. The number of years of teaching experience that a teacher has completed did not form a significant relationship with either variable. Pay scales and tenure are determined by the number of years a teacher has taught. A review of alternate ways to develop pay scales could provide additional data for decision making within school districts. The second variable with no significant relationship was type of endorsement. Principals place teachers into classrooms based on endorsement type. NCLB requires that every classroom has a highly qualified teacher, and this qualification is based on endorsement type found on the teaching license. Yet, this study found no significant relationship. Pedagogy and content knowledge as well as math teaching efficacy did not have a statistically significant relationship with endorsement type. This data indicates that endorsement type will not adequately inform an administrator that a teacher is highly qualified to teach mathematics in the primary classroom.

Implications for Practice

A teacher's career typically follows a particular path from college student to classroom teacher. The usual timeline would include college preparation, licensure, hiring, and then teaching. Each step in this journey contains key points of training and development. The data from this study sheds some light on some important processes that require review and refinement from college program developers, policy makes, school principals and district administrators.

College preparation experiences. College preparation experiences included endorsement type, highest degree earned and level of mathematics study. From this study only one of these variables demonstrated a significant relationship, PCK and highest degree earned (ρ=.143, p<.05). Identifying this as a significant relationship may increase the number of primary grade teachers that continue to seek higher education experiences. Colleges decide the type of experiences that these teachers receive. It would be worthy of further investigation to identify experiences that would be most important in relation to teacher preparation and professional development and student learning in mathematics at the primary level.

A second implication for practice is the need to evaluate the endorsement programs provided at schools of higher education. For endorsement type to have no statistically significant relationship with teaching knowledge and teaching efficacy gives cause to question the way endorsement paths are structured. Teacher preparation programs should do just that; prepare teachers for teaching in the classroom for which they will be endorsed. If a teacher leaves a teacher preparation program underprepared, then the college program has adversely influenced educational practices for thousands of students in classrooms across America.

Licensure. NCLB requires that every classroom teacher be deemed "highly qualified." Each state government determines the process requirements to identify a "highly qualified" teacher. Each State Board of Education votes into law the requirements a teacher must possess to obtain a teaching license. Teachers earn these licenses, and from this license/endorsement, teachers are hired to teach students in a classroom. Principals must trust that every teacher with the given endorsement is equipped with the essential skills to teach competently. When a teacher has earned the state license, a principal assumes that the teacher is able to teach all subjects in the endorsed areas, i.e. K-3 or K-6 or even K-8 education. It means that this teacher has the content knowledge and pedagogical skills necessary for this teacher to teach and thus have a positive impact on student learning. The data in this study shows that no statistically significant relationship exists between a teacher's endorsement and the teacher's pedagogical and content knowledge. In addition, this endorsement data did not have a statistically significant relationship with the teacher's level of math teaching efficacy. It would be wise for policy makers to reflect deeply on the data from this study.

Hiring. School districts are involved in the next step in the process, hiring of a teacher. School districts must follow the laws provided by the Departments of Education. When an elementary school has a kindergarten, first grade or second grade job opening, typically, the human resource (HR) department lists the job opening on the district job page. When the closing date arrives, the HR department will shuffle through the applicants to ensure that each applicant has the appropriate endorsement area. This is the first step in the filtering process. Once again, it is assumed that if the teacher has the appropriate endorsement, then the teacher should be able to be an effective teacher. At this point, the administrator shuffles through the applications to select an appropriate candidate pool. This is where the interview process starts. In most districts, the applicants are then required to complete a writing sample. From the data collected in this study, one suggestion would be that applicants would to institute a mathematics skill assessment that would allow the applicants to demonstrate their ability to answer a bank of grade three mathematics problems. This would provide the administrator with baseline data concerning the mathematics ability and understanding of the applicant. From this baseline data, the district and/or school administrator could support the teacher based on his/her level of understanding for mathematics.

Work experiences and math professional learning. Variables contained in this topic included years of teaching experience in grades K, one, and two; years teaching experience in grades three, four, and five; and total years teaching experience. It is interesting to note that number of years of teaching experience did not form a statistically significant relationship with either PCK or MTEB. The data made it apparent that teachers in the primary grades tend to have experience only in those grades. Even though the smallest teacher endorsement for the elementary grades is PK3, the percent of teachers that actually taught in grade three was relatively small. It would be interesting to see if requiring all primary grade teachers to teach in grade three for some time before moving to the primary grades would make an improvement with pedagogy and content knowledge as well as math teaching efficacy. In addition, this experience may have a positive impact on the teaching skill and knowledge required for the primary grades.

Educational leaders, such as principals, district math coordinators/supervisors, and district curriculum professional development planning teams may find this information helpful in developing better support for primary grade teachers. It is evident from the analyses of the data obtained in this study that math professional learning experiences have a statically significant relationship with the pedagogy and content knowledge of primary grade teachers. Instituting an ongoing mathematics professional learning structure could support the development of the primary grade teacher. One suggestion is that school districts collaborate with the faculty at institutes of higher education in the school of education, to develop math professional learning programs that would support preservice, new, and experienced primary grade teachers in their role as instructors of mathematics. Combining college knowledge with school district knowledge of strengths and weakness may make for a strong, positive working environment that benefits the primary grade classroom teachers and their students.

Recommendations for Further Research

As indicated in the limitations section, researchers need to conduct many more studies to continue this preliminary investigation. There are two cautions that need consideration in this study. First, a 30-question instrument was the sole source of data in determining a teacher's math pedagogy and content knowledge level. Classroom observations and teacher dialogue would have provided a more complete picture and understanding of teacher quality. Second, at this time there is no student achievement data available to determine the effectiveness of a teacher in terms of student achievement. Regardless, this study raises issues that need more time and attention from other vantage points.

Recommendations for future study include:

1. A replication study that focuses on third grade teachers. This would provide baseline data for the primary grade teacher research.
2. A replication study that contains more primary grade teachers. This would allow for some generalizations that would influence the greater good.
3. Further research on the relationships between math teaching efficacy, and math pedagogy and content knowledge.
4. A similar study with either upper elementary, middle school, or high school teachers. This would provide some additional background data involving the use of instruments selected for this study.
5. An experimental design study using the survey instrument to measure change in teachers efficacy, and pedagogy and content knowledge.

Conclusion

In final reflection, there are three important take-a-ways from this study. First, administrators should create math professional learning opportunities for primary grade teachers in order to increase teacher knowledge in regards to third grade mathematics. Second, at this time the endorsement and license type does not necessarily indicate a teacher's ability to teach mathematics in the primary grade classroom. Administrators should tread cautiously when making employment decisions. Third, there is a statically significant relationship between math teaching efficacy and pedagogical and content knowledge. Careful consideration is necessary to determine how to impact student learning by increasing math teaching efficacy as well as math pedagogical and content knowledge of teachers in the primary grades.

We know through Hattie's work that teachers are a key component of the educational process (2012). This study adds to the existing body of literature on mathematics curriculum instruction, focusing on an area that has had little attention. Findings from this study will broaden the understanding of the ways in which primary teachers affect the vertical math curriculum sequence. By searching for relationships and identifying variables that have statistically significant relationships, school administrators and school district leaders can promote positive changes in professional learning experiences as well as provide teachers the time and support they need in order to grow in their professional knowledge and efficacy.

APPENDIX

Appendix A:

VA School of Education Conceptual Frameworks

College	Knowledge	Assessment	Leadership	Reflection
Bluefield College	Knowledge			Cooperative-reflective manager
College of William and Mary	content expert		educational leader	Reflective Practitioner
Eastern Mennonite University	Scholarship Inquiry Professional knowledge		leadership	
Hampton University	Content specialty			
James Madison University	content	assessing		reflection
Liberty University	knows			
Longwood University	Content knowledge	Evaluation/ assessment		Evaluation/ assessment
Marymount University	educate		Lead	
Radford University	knowledge			
Randolph College		assessment		
Regent University	knowledge			
Roanoke College	Pedagogy content			
Virginia State University			Educational leader	The reflective practitioner
Virginia Union University	Studies Academic major			teacher as reflective explorer

Appendix B: Informed Consent Form

Participant Informed Consent Form
College of William & Mary

Purpose of the Study:
This study of primary mathematics teaching beliefs and knowledge is being conducted by Theresa Roettinger, mathematics coordinator in Williamsburg, Virginia. The purpose is to investigate relationships that may exist between teachers' mathematics teaching beliefs, their content knowledge and their mathematics teaching profile.

What will be done:
You will complete an online survey, which will take approximately 30 minutes to complete. The survey contains three parts. Part 1 collects information regarding your college preparation experiences, your work experiences and our professional development experiences. Part 2 collects information about your beliefs regarding your teaching of mathematics. Part 3 collects information about your mathematics teaching style and understanding. After all participants complete the questionnaire, I will analyze the data to see if there are any relationships or patterns found.

Benefits of this Study:
Any relationships that are found through the data analysis may benefit professional development initiatives focused on primary grade mathematics teaching. In addition, if you choose to submit your email address, you will be entered into a drawing for an iPad mini. After the data collection process is completed, the drawing will occur. Delivery arrangements will be made via email. All participants that submit their email address will receive an email with detailed information about the research findings.

Risks or discomforts:
No risks or discomforts are anticipated from taking part in this study. If you feel uncomfortable with a question, you can skip that question or withdraw from the study altogether. If you decide to quit at any time before you have finished the questionnaire, your responses will NOT be recorded.

Confidentiality:
Your responses will be kept completely confidential. You will be asked to submit your first, middle, and last initials on this informed consent form for documentation purposes, but this information will not be connected to your survey responses. Your email will be used as part of the drawing and post-data analysis reporting and will not be connected to your survey responses. Instead, you will be assigned a participant number, and only the participant number will appear with your survey responses. After the data is collected, the prize awarded, and a report of the results of the study has been sent to your email address, the list of participants' email addresses will be destroyed.

Decision to quite at any time:
Your participation is voluntary: you are free to withdraw your participation from this study at any time. If you do not want to continue, you can simple leave the website. If you do not complete the survey your answers and participation will not be included in the analysis. If you complete the survey, then you will be entered into the drawing.

How the findings will be used:
The results of this study are for scholarly purposes only. The results from the study will be presented in educational settings and may be published in a professional journal in the field of mathematics education.

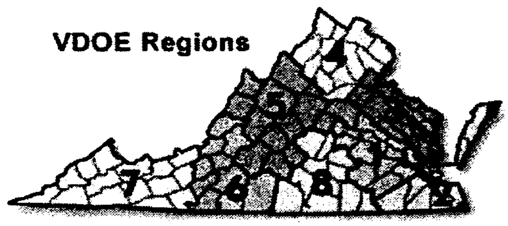
Consent:
The general nature of this study entitled Primary Grade Teachers' Mathematics Teacher Profile, Mathematics Teaching Beliefs, and Mathematics Pedagogical Content Knowledge, conducted by Theresa Roettinger has been explained to me. I understand that I will be asked to complete an online survey. My participation in this study should take a total of about 30 minutes. I understand that my responses will be anonymous so that my identity will not be known or connected to responses and that my name will not be associated with any results of this study. I know that I may refuse to answer any question asked and that I may discontinue participation at any time. Potential risks resulting from my participation in this project have been described to me. I am aware that I may report dissatisfactions with any aspect of this experiment to the Chair of the Protection of Human Subjects Committee, Dr. Lee Kirkpatrick, 757-221-3997 or lakirk@wm.edu. I am aware that I must be at least 18 years of age to participate.

By beginning the survey, I acknowledge that I have read this information and agree to participate in this research, with the knowledge that I am free to withdraw my participation at any time without penalty.

Appendix C: Survey

Part 1: Mathematics Teacher Profile

In what region of the state do you currently teach?



_____ Region 1 _____ Region 2 _____ Region 3 _____ Region 4
_____ Region 5 _____ Region 6 _____ Region 7 _____ Region 8

This school year, what grade level(s) are you teaching? (Mark all that apply.)
_____ Kindergarten _____ First _____ Second

COLLEGE PREPARATION EXPERIENCES

Please select one.
_____ I majored in mathematics. _____ I minored in mathematics. _____ Neither

Please mark your highest degree earned from the following list:
_____ Bachelor's degree _____ Master's degree
_____ Bachelor's + Post-baccalaureate coursework _____ Ed. S/CAGS
_____ Doctorate

Please select the type of teaching endorsement(s) you currently have. (Mark all that apply.)
_____ PK-3 _____ PK-6 _____ PK-8 Math Specialist Other

WORK EXPERIENCE

Please select from the drop down menu the number of years you have taught at each of the following grade bands (including the current year).
K, 1st, 2nd **0-50 years** 3rd, 4th, 5th **0-50 years** 6th, 7th, 8th **0-50 years**

IN-SERVICE PROFESSIONAL DEVELOPMENT EXPERIENCS

Please select from the drop down menu the number of mathematics courses you successfully completed after college. **0 – 10+**

Are you a National Board Certified Teacher? _____ Yes _____ No

During the past 5 years, how frequently have you participated in professional development focusing on mathematics?
_____ Never _____ Seldom _____ Occasionally _____ Frequently

Part 2: Mathematics Teaching Efficacy Beliefs Instrument

	Strongly	Agree	Uncertain	Disagree	Strongly

	Agree				Disagree
1. When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.	SA	A	UN	D	SD
2. I will continually find better ways to teach mathematics.	SA	A	UN	D	SD
3. Even if I try very hard, I will not teach mathematics as well as I will most subjects.	SA	A	UN	D	SD
4. When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA	A	UN	D	SD
5. I know how to teach mathematics concepts effectively.	SA	A	UN	D	SD
6. I will not be very effective in monitoring mathematics activities.	SA	A	UN	D	SD
7. If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.	SA	A	UN	D	SD
8. I will generally teach mathematics ineffectively.	SA	A	UN	D	SD
9. The inadequacy of a student's mathematics background can be overcome by good teaching.	SA	A	UN	D	SD
10. When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher.	SA	A	UN	D	SD
11. I understand mathematics concepts well enough to be effective in teaching elementary mathematics.	SA	A	UN	D	SD
12. The teacher is generally responsible for the achievement of students in mathematics.	SA	A	UN	D	SD
13. Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.	SA	A	UN	D	SD
14. If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.	SA	A	UN	D	SD
15. I will find it difficult to use manipulatives to explain to students why mathematics works.	SA	A	UN	D	SD
16. I will typically be able to answer students' questions.	SA	A	UN	D	SD
17. I wonder if I will have the necessary skills to teach mathematics.	SA	A	UN	D	SD
18. Given a choice, I will not invite the principal to evaluate my mathematics teaching.	SA	A	UN	D	SD
19. When a student has difficulty understanding a mathematics concept, I will usually be at a loss as to how to help the student understand it better.	SA	A	UN	D	SD
20. When teaching mathematics, I will usually welcome student questions.	SA	A	UN	D	SD
21. I do not know what to do to turn students on to mathematics.	SA	A	UN	D	SD

PART 3: Pedagogical and Content Knowledge EXAMPLE ITEMS

LEARNING MATHEMATICS FOR TEACHING

MATHEMATICAL KNOWLEDGE FOR TEACHING (MKT) MEASURES

MATHEMATICS RELEASED ITEMS 2008

University of Michigan, Ann Arbor
610 E. University #1600
Ann Arbor, MI 48109-1259
(734) 647-5233
www.sitemaker.umich.edu/lmt

 Measures development supported by NSF grants REC-9979873, REC- 0207649, EHR-0233456 & EHR 0335411, and by a subcontract to CPRE on Department of Education (DOE), Office of Educational Research and Improvement (OERI) award #R308A960003.

December 26, 2008

Study of Instructional Improvement/Learning Mathematics for Teaching
Content Knowledge for Teaching Mathematics Measures (MKT measures)
Released Items, 2008

ELEMENTARY CONTENT KNOWLEDGE ITEMS

1. Ms. Dominguez was working with a new textbook and she noticed that it gave more attention to the number 0 than her old book. She came across a page that asked students to determine if a few statements about 0 were true or false. Intrigued, she showed them to her sister who is also a teacher, and asked her what she thought.

Which statement(s) should the sisters select as being true? (Mark YES, NO, or I'M NOT SURE for each item below.)

	Yes	No	I'm not sure
a) 0 is an even number.	1	2	3
b) 0 is not really a number. It is a placeholder in writing big numbers.	1	2	3
c) The number 8 can be written as 008.	1	2	3

3. Imagine that you are working with your class on multiplying large numbers. Among your students' papers, you notice that some have displayed their work in the following ways:

Student A	Student B	Student C
35 x25 125 +75 875	35 x25 175 +700 875	35 x25 25 150 100 +600 875

Which of these students would you judge to be using a method that could be used to multiply any two whole numbers?

	Method would work for all whole numbers	Method would NOT work for all whole numbers	I'm not sure
a) Method A	1	2	3
b) Method B	1	2	3
c) Method C	1	2	3

9. Ms. James' class was investigating patterns in whole-number addition. Her students noticed that whenever they added an even number and an odd number the sum was an odd number. Ms. James asked her students to explain why this claim is true for all whole numbers.

After giving the class time to work, she asked Susan to present her explanation:

> I can split the even number into two equal groups, and I can split the odd number into two equal groups with one left over. When I add them together I get an odd number, which means I can split the sum into two equal groups with one left over.

Which of the following best characterizes Susan's explanation? (Circle ONE answer.)

a) It provides a general and efficient basis for the claim.

b) It is correct, but it would be more efficient to examine the units digit of the sum to see if it is 1, 3, 5, 7, or 9.

c) It only shows that the claim is true for one example, rather than establishing that it is true in general.

d) It assumes what it is trying to show, rather than establishing why the sum is odd.

KNOWLEDGE OF CONTENT AND STUDENTS ITEMS

10. Mr. Garrett's students were working on strategies for finding the answers to multiplication problems. Which of the following strategies would you expect to see some elementary school students using to find the answer to 8 x 8? (Mark YES, NO, or I'M NOT SURE for each strategy.)

	Yes	No	I'm not sure
a) They might multiply 8 x 4 = 32 and then double that by doing 32 x 2 = 64.	1	2	3
b) They might multiply 10 x 10 = 100 and then subtract 36 to get 64.	1	2	3
c) They might multiply 8 x 10 = 80 and then subtract 8 x 2 from 80: 80 – 16 = 64.	1	2	3
d) They might multiply 8 x 5 = 40 and then count up by 8's: 48, 56, 64.	1	2	3

11. Students in Mr. Hayes' class have been working on putting decimals in order. Three students — Andy, Clara, and Keisha — presented 1.1, 12, 48, 102, 31.3, .676 as decimals ordered from least to greatest. What error are these students making? (Mark ONE answer.)

a) They are ignoring place value.

b) They are ignoring the decimal point.

c) They are guessing.

d) They have forgotten their numbers between 0 and 1.

e) They are making all of the above errors.

13. Mrs. Jackson is getting ready for the state assessment, and is planning mini-lessons for students focused on particular difficulties that they are having with adding columns of numbers. To target her instruction more effectively, she wants to work with groups of students who are making the same kind of error, so she looks at a recent quiz to see what they tend to do. She sees the following three student mistakes:

	1		1		1
I)	38	II)	45	III)	32
	49		37		14
	+ 65		+ 29		+ 19
	142		101		64

Which have the same kind of error? (Mark ONE answer.)

a) I and II

b) I and III

c) II and III

d) I, II, and III

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